AD-A260 160

(2)

ESL-TR-91-18

THE SYNERGISTIC EFFECTS OF COMBINED BLAST AND FRAGMENT LOADINGS

K. A. MARCHAND, M. M. VARGAS,
J. D. NIXON

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
P.O. DRAWER 28510
SAN ANTONIO, TX 28228-0510

93-01570

JANUARY 1992

FINAL REPORT

MARCH 1989 - JULY 1991

APPROVED FOR PUBLIC RELEASE:
DISTRIBUTION UNLIMITED

AFESC

AIR FORCE ENGINEERING & SERVICES CENTER
ENGINEERING & SERVICES LABORATORY
TYNDALL AIR FORCE BASE, FLORIDA 32403

NOTICE

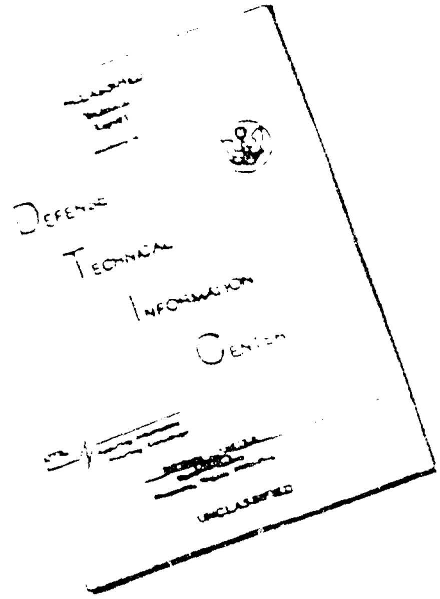
PLEASE DO NOT REQUEST COPIES OF THIS REPORT FROM HQ AFESC/RD (ENGINEERING AND SERVICES LABORATORY). ADDITIONAL COPIES MAY BE PURCHASED FROM:

NATIONAL TECHNICAL INFORMATION SERVICE
5285 PORT ROYAL ROAD
SPRINGFIELD, VIRGINIA 22161

FEDERAL GOVERNMENT AGENCIES AND THEIR CONTRACTORS REGISTERED WITH DEFENSE TECHNICAL INFORMATION CENTER SHOULD DIRECT REQUESTS FOR COPIES OF THIS REPORT TO:

DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22314

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release. Distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) ESL-TR-91-18
6a. NAME OF PERFORMING ORGANIZATION Southwest Research Institute Project 06-2821 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Air Force Engineering and Services Center
6c. ADDRESS (City, State, and ZIP Code) 6220 Culebra Road P.O. Drawer 28510 San Antonio TX 28228-0510	7b. ADDRESS (City, State, and ZIP Code) HQ AFESC/RACS Tyndall AFB FL 32403-6001
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER FO 8635-89-0195
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

The Synergistic Effects of Combined Blast and Fragment Loadings (U)

12. PERSONAL AUTHOR(S)

Marchand, K.A.; Vargas, M.M.; Nixon, J.D.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 89-03 TO 91-07	Jan 1992	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Synergistic Effects, Blast Loads, Fragments Loads, Breaching, Combined Loading

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels. Finally, the data was evaluated and the observed synergism was quantified. A factor of four enhancement of stress due to the synergistic effects of the blast and fragments in the concrete and fibrous concrete slabs was observed.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL James M. Underwood, LT CECUSN	22b. TELEPHONE (Include Area Code) (904) 283-4932	22c. OFFICE SYMBOL HQ AFESC/RACS

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

(The reverse of this page is blank.)

EXECUTIVE SUMMARY

A. OBJECTIVE

The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both.

B. BACKGROUND

Simultaneous impact and blast loads applied to a structure can cause responses that in some cases are more severe than the sum of the damage generated in the structure through the independent application of the loads. Hence, this simultaneous loading is considered to be *synergistic* in the sense that the simultaneous damage is greater than the sum of the impact and non-impact loadings.

C. SCOPE

Tests and analysis were conducted to define this synergism. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels.

D. CONCLUSIONS

The important comparison that was made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. It is important to note that these comparisons are being made for charges of *equivalent impulse*, not simply equivalent explosive weight. The fragment impulse is being accounted for in the bare charge equivalent weight.

1) The heavily cased charges (2.4 lb. cased) in tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7 lb. cased, test 13) by a factor of 1.7 in the Type B panel.

2) The heavily cased charge produced stresses 4 times higher than the equivalent bare charge for the Type B panel.

3) In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance.

E. RECOMMENDATIONS

Future work in the definition of the synergism in blast and fragment loadings should include a second phase of laboratory testing and some additional analysis as well as some effort to integrate the information derived from research and testing into design guidance for protective construction. These phases could be conducted as follows:

PHASE II:

(1) *Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen.*

(2) *Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations.*

PHASE III:

(1) *Analytic model development/refinement*

(2) *Selection of optimum materials and structural configurations*

PREFACE

This work has been prepared as required by Contract F08635-89-C-0195 for the Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida, as administered by the Department of the Air Force Munitions System Division, (MSD/PMR) at Eglin Air Force Base, Florida. The work has been carried out under Southwest Research Institute (SwRI) Project 06-2821.

The HQ AFESC/RDCS project officer for the program was Lt. James Underwood at AFESC/RDCS. The work reported has been accomplished by Messrs. Kirk A. Marchand and Luis M. Vargas of the Structural Engineering Department and Jerry D. Nixon of the Materials Sciences Department of the Engineering and Materials Sciences Division at SwRI. Dr. Ulric S. Lindholm is the Vice President of the Engineering and Materials Sciences Division and is also Director of the Structural Engineering Department. Work was accomplished between March 1989 and July 1991.

The authors would like to thank Messrs. M. Ray Burgamy and Joe Elizondo for their efforts in conducting the experiments and to Ms. Terry Sloan for her efforts in preparing the manuscript.

William S. Strickland

WILLIAM S. STRICKLAND, GM-14
Chief, Air Base Survivability Branch

NEIL H. FRAVEL, Lt Col, USAF
Chief, Engineering Research Division

FRANK P. GALLAGHER III, Col, USAF
Director, Engineering and Services Laboratory

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

(The reverse of this page is blank.)

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

(The Reverse of this page is blank)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

(The reverse of this page is blank.)

SECTION I

INTRODUCTION

A. OBJECTIVE

The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels. Finally, the data were evaluated and the observed synergism was quantified.

B. BACKGROUND

In the design and analysis of protective structures designed to resist the attack of modern conventional weaponry, many methods are available for the prediction of dynamic response of the structure of concern (References 1-4). Additionally, several methods for the prediction of projectile and fragment penetration are available for these same structural varieties. What is missing, and is typically not addressed in a design or simplified analysis reference, is the effect of combined load types such as simultaneously applied impact and non-impact, yet impulsive, loadings.

The effect of simultaneous loadings has been observed, however, and the differences in structure responses as compared to separately applied loads of the same type are severe. In some early Waterways Experiment Station work (Reference 5) concerning the testing of field fortifications used in the Vietnam War years, it was noted that the integrity of reinforced concrete walls loaded with artillery shells detonated in close proximity to the fortifications (5-15 feet) was dependent on the use of sandbags placed in front of the walls. The sandbags in these tests provided a measure of protection from the impact loading generated by the fragments. Recent work at Southwest Research Institute (SwRI) (Reference 6) has shown that the damage caused by the combined impact and blast loading of a steel flyer plate is significantly more damaging to concrete barrier panels than the loading generated by approximately three times the weight of uncased explosive. Other work reported by Coltharp, et al. (Reference 7) has provided additional information concerning the necessity of fragment protection.

It can be shown, then, that simultaneous impact and blast loads applied to a structure can cause responses that in some cases are more severe than the sum of the damage generated in the structure through the independent application of the loads. Hence, this simultaneous loading is considered to be *synergistic* in the sense that the simultaneous damage is greater than the sum of the impact and non-impact loadings.

A rationale, both analytically and empirically supported, is needed by the hardened structure designer and vulnerability analyst to define the response modes and degree of response expected from synergistic blast and fragment loadings. Significant test data and applicable analytic tools are available which could allow design or analysis information to be generated which would adequately predict and account for these kinds of structural responses.

Southwest Research Institute (SwRI) is currently conducting a study to consider and define the synergism of blast and fragment impact on structures, and the resulting structural damage modes and response. This work is being performed in the form of a combined structural test series and analysis program.

C. PURPOSE AND SCOPE

The effort described above is being performed in three phases. This interim technical report documents Phase I testing and existing analytic model evaluation. This Phase I Literature Search is complete and has been provided under separate cover (Reference 8). Phases II and III are discussed in limited detail below. The three Phases will include the following activities as a minimum:

PHASE I:

(1) Comprehensive literature search

(2) Testing of threats and materials to quantify the synergistic effects as they vary with material type, threat type, and munition proximity

(3) Evaluation of available response models concurrent with testing

PHASE II:

(1) Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen

(2) Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations

PHASE III:

(1) Analytic model development/refinement to allow the prediction and definition of synergistic effects, response modes, and response magnitude

(2) Selection of optimum materials and structural configurations for combined blast and fragment loading scenarios

This interim report describes work partially satisfying the requirements of Phase I. A detailed final report will subsequently be prepared which will include completed data reduction and detailed data analysis.

SECTION II

TEST PLAN, SETUP AND INSTRUMENTATION

The objective of the program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels.

All tests described in the following paragraphs were conducted at the SwRI ballistics range on the SwRI campus. The complete test matrix is shown in TABLE 1.

A. DESIGN OF SCALED BARE AND CASED EXPLOSIVE CHARGES

The bare and cased charge tests were conducted using two types of simulated bombs, the U.S. Mk 82, GP 500 bomb which is a lightly cased bomb; and the U.S. AN-Mk 1, AP 1600 bomb which is a heavily cased bomb. Physical characteristics and other details on both the Mk 82 and the AN-Mk 1 are provided in TABLE 2 and in Figure 1 of this report. Since SwRI's on-site test facility has a 3-pound aboveground TNT explosive limit, the scale model size selected for these tests was a 1:4.3 scale which allowed for the conduct of the tests on-site. Physical dimensions for the scaled munitions are also included in TABLE 2. Fabrication details for each simulated bomb are provided in the following paragraphs:

Mk 82 GP 500 Bomb - The scaled model Mk 82 was fabricated using commercially available 2.5 inch O.D. round carbon steel tubing. The scaled wall thickness used was 0.065 inch which scales within 6 percent of the full scale bomb casing thickness which is 0.3 inches (Reference 1). As shown in TABLE 2, the Mk 82 contains 192 pounds of H-6 explosive (Reference 1) which converts to an equivalent weight of TNT of 243 pounds. Using a 1:4.3 scale, the charge weight scales down to 3 pounds of TNT (charge weight scales down by the scale factor cubed). SwRI used composition C4 explosive to simulate the TNT. Since C4 has a TNT equivalency of 1.129, the simulated cased charge explosive weight was 2.707 pounds of C4. The scaled bomb length was sized to be the exact length of a cylinder of C4 explosive having a diameter of 2.372 inches and weighing 2.707

pounds. This explosive cylinder length was calculated to be 10.7 inches using a density of C4 of .0574 pounds/cubic inch. Figure 1 shows the modeled Mk 82 bomb.

AN-Mk 1 AP 1600 Bomb - The scaled model AN-Mk 1 was also fabricated using commercially available carbon steel round tubing. The tubing selected had a 3.25-inch O.D. with a wall thickness of 0.375. The desired scaled wall thickness as shown in TABLE 2 is 0.302 inches and the tubing wall was machined down to the correct thickness from the inside of the tube thereby increasing the inner diameter. The full-scale bomb case thickness given in Reference 12 is 1.3 inches. The AN-Mk 1 bomb has 215 pounds of TNT (Reference 12) which scales down to 2.7 pounds of TNT for the scaled bomb. SwRI used C4 on these tests. The comparable C4 explosive charge was 2.39 pounds. The scaled bomb length for this bomb was also calculated by determining the corresponding length of a C4 explosive cylinder with a diameter of 2.65 inches and weighing 2.39 pounds. The length was 7.54 inches. Figure 1 shows the modeled AN-Mk 1 bomb.

B. TASK 1 - LOADS TESTS

1. Task 1A - Bare Charge Tests

Bare explosive charge tests were conducted first to validate an instrumentation and reaction structure designed for close-in, nonuniform (nonspherical) explosive charge loads determination. Five of these tests were conducted. Although the fixture was somewhat damaged in later cased charge tests, and was not used further in the program, it proved to be effective in loads determination for bare explosive charges.

a. Test Description

The scaled bare charge tests were conducted in a reaction structure consisting of a 6 foot x 8 foot x 8 foot reinforced concrete culvert. The concrete culvert was reinforced using 0.5-inch steel plates which were attached to the sides and floor of the culvert as shown in Figure 2. An impulse plug fixture used to measure the specific impulse at various radii from the center point of the charge was located at the east end of the concrete culvert as shown in Figure 3. The bare C4 charge was centered vertically in the reaction structure and was initiated remotely using an RP-83 detonator. The pulse to initiate the detonator originated from the high-speed camera used to document the test.

The impulse plug fixture was fabricated out of 6-inch thick steel plate. A number of holes were drilled into the plate for positioning the impulse plugs (I1-I8) and for positioning the

TABLE 1. TEST MATRIX FOR PHASE I TESTS.

Test No.	Charge	Panel Type	Standoff	Instrumentation*	Date Complete
1	2.4 bare	Impulse Plate	18"	RP( ), IP(8), SP(4)	11/2/89
2	2.7 bare	"	"	RP( ), IP(8), SP(4)	11/7/89
3	2.4 bare	"	"	RP( ), IP(8), SP(4)	11/13/89
4	2.7 bare	"	"	RP( ), IP(8), SP(4)	11/27/89
5	2.4 bare	"	"	RP( ), IP(8), SP(2)	12/13/89
6	2.7 cased	"	"	SP(2), VS(4), F	12/13/89
7	2.4 cased	"	"	SP(2), VS(4), F	1/8/90
8	2.4 cased	"	"	SP(2), VS(4), F	1/12/90
9	2.7 cased	Type A	6"	V, HS	3/30/90
10	2.4 equiv.	"	6"	V, HS	4/4/90
11	2.4 cased	"	6"	V, HS	4/25/90
12	2.8 equiv.	"	7"	V, HS	4/27/90
13	2.7 cased	Type B	6"	V, HS, ES(4), PC(8)	4/5/90
14	2.4 equiv.	"	6"	V, HS, ES(4), PC(8)	4/19/90
15	2.4 cased	"	6"	V, HS, Es(4), PC(8)	5/1/90
16	2.8 equiv.	"	7"	V, HS, ES(4), PC(8)	5/4/90
17	2.7 cased	Type C	6"	V, HS	4/30/90
18	2.4 equiv.	"	6"	V, HS	4/30/90
19	2.4 cased	"	6"	V, HS, ES(4), PC(8)	5/3/90
20	2.8 equiv.	"	7"	V, HS, ES(4), PC(8)	5/4/90

* IP = impulse plugs
RP = reflected pressure
ES = embedded stress (carbon film gage)
SP = side-on pressure
VS = velocity screens
F = fiberboard frag trap
V = video
HS = high-speed film
PC = piezocrystal (TOA)

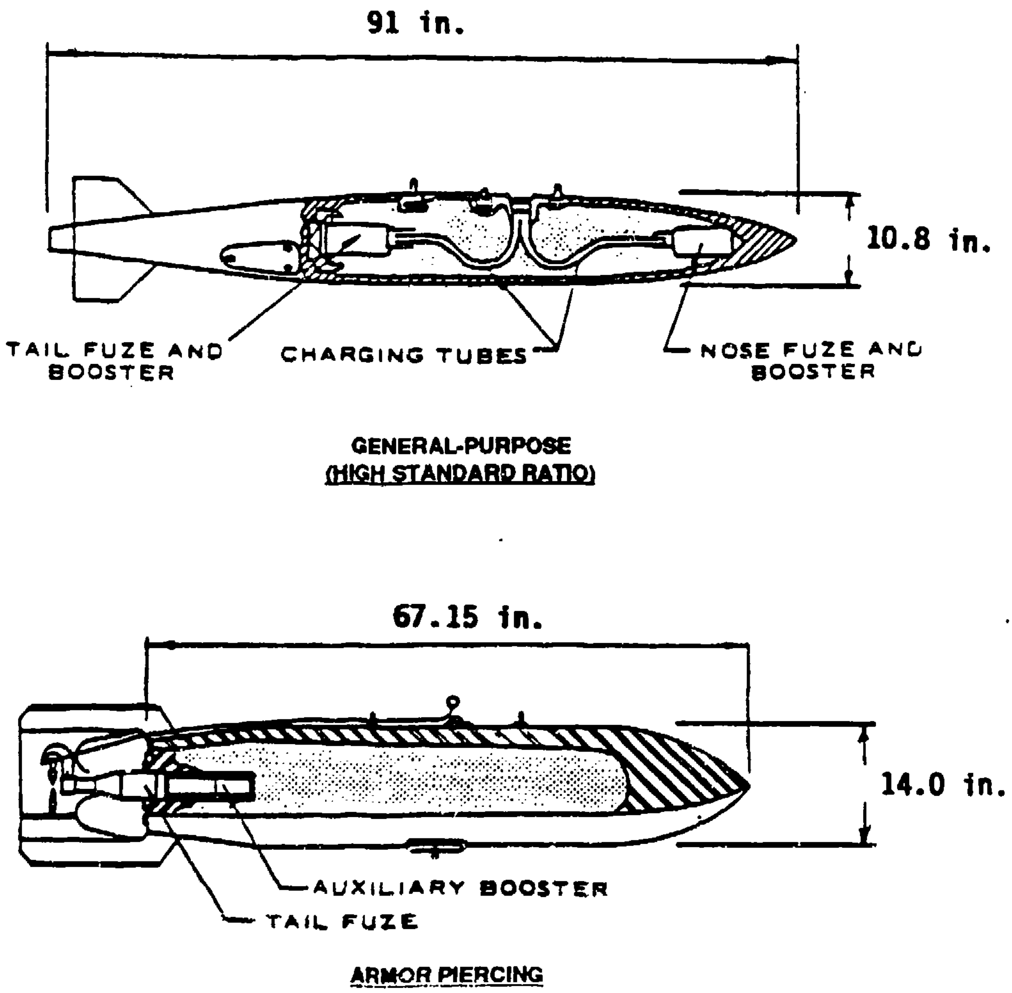


Figure 1. Physical Descriptions of Mk 82 and AN-Mk 1 Bombs.

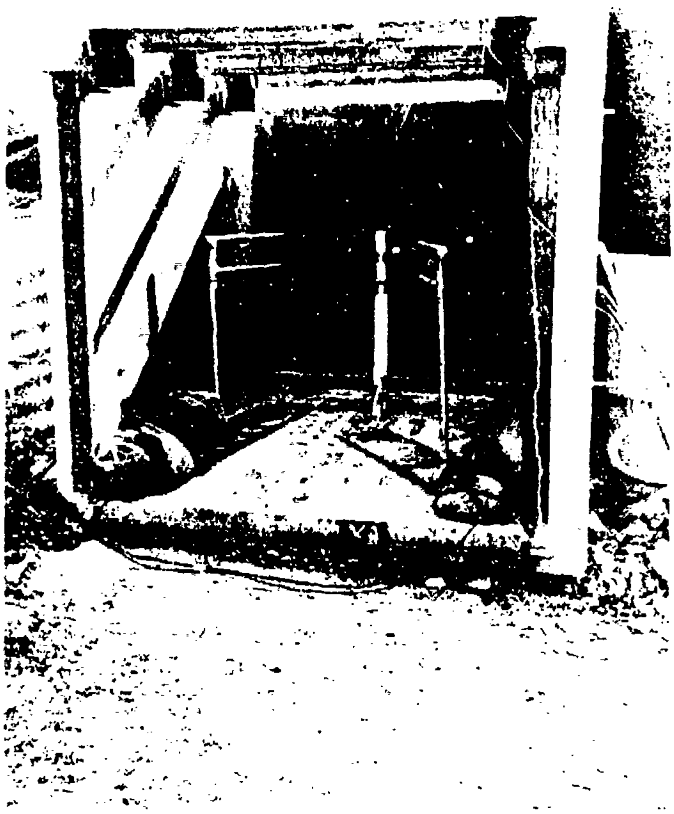


Figure 2. Reaction Structure for Testing.

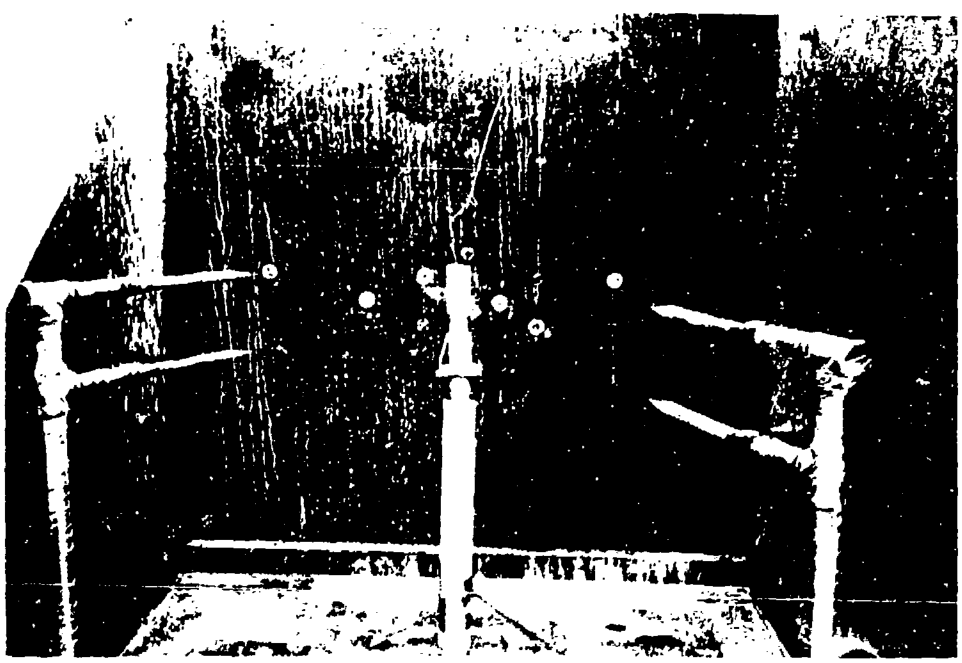


Figure 3. Charge and Impulse Plate Location for Loads Tests.

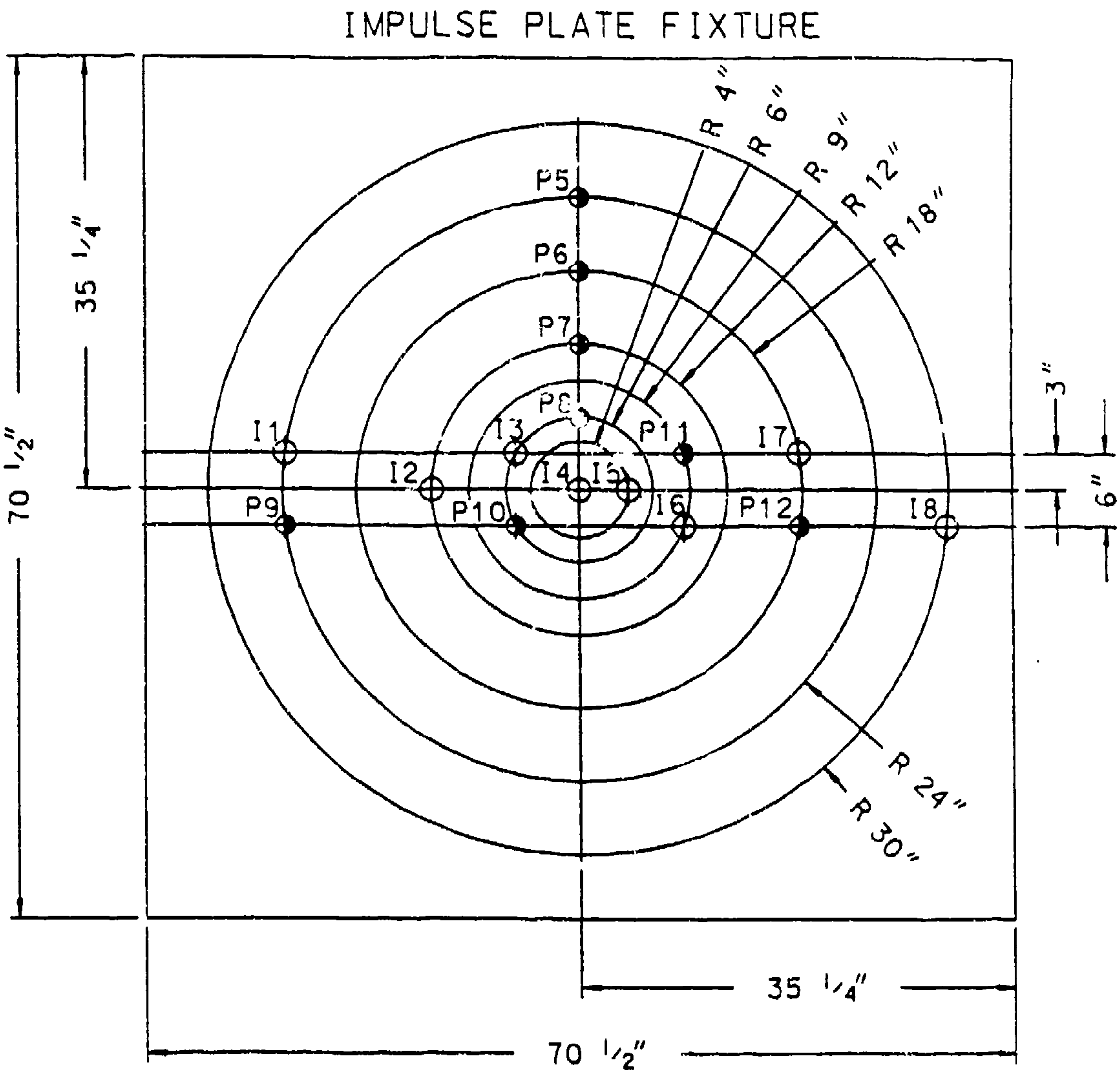


Figure 4. Schematic of the Impulse Plate.

Figure 5. Impulse Plugs.

reflected pressure gages (P5-P12). A schematic of the impulse plug fixture is provided here as Figure 4. The impulse plugs used in the test fixture are shown in Figure 5; 2-inch diameter plugs were used and consisted of a thin steel tube 6 inches long with either a 0.188-inch thick steel cap or with a 0.188-inch thick aluminum cap. The heavier steel cap was selected for use in those tests where the expected impulse would be large, resulting in a relatively high plug velocity. The heavier cap would slow the plug to allow for accurate recording with the high-speed cameras. The aluminum cap was selected for those tests where the expected impulse would be low, resulting in a low plug velocity where the lighter cap would enable the plug to exit at a high enough velocity where it could be captured on high-speed film. The actual velocities of the plugs were initially measured using fiber-optic break cables and switching circuitry located on the back of the impulse plug fixture which would emit an electrical signal when broken. This approach performed very well; however, the higher cost of the fiber-optic cable made it desirable to replace the cables with Dynasen position transducers or shorting pins (Reference 9). These position transducers produce an electrical signal when the tip of the transducer is impacted by a rapidly moving object, such as a shock front or an ionization front. Each set of shorting pins consisted of a 7-inch pin and a 1-inch pin and both were mounted on an assembly which was positioned on the back of the impulse plug fixture (Figure 6). This configuration enabled each set of pins to be located inside of each of the impulse plug tubes such that the longer pin was 0.5 inches from the back of the plug cap. Once the explosive charge was detonated, the plugs were driven out of the plate, and the base of the cap impacted the pins which in turn gave an output which was recorded on magnetic tape. The time that each pin shorted and the distance between pins was used to calculate the individual plug velocities. The velocity and plug mass and area were then used to determine the momentum and specific impulse imparted to the plugs.

Both side-on and reflected pressure gages were used in the bare charge tests. The side-on pressures were measured at two different standoffs using two gages at each standoff. The two gages were located six inches apart as shown in Figure 7. Six reflected pressure measurements were made using gages mounted in the impulse plug fixture. Measurements of the impulse distribution for the bare charge tests were made at various radii from the center point adjacent to the charge using the impulse plug test fixture. Figure 4 shows the gage layout and numbering scheme.

A total of five bare charge tests were conducted. Three tests were conducted using the 2.4-pound bare charge and two tests were conducted using the 2.7-pound bare charge. For each of the tests, the center of the charge was positioned 36 inches above the

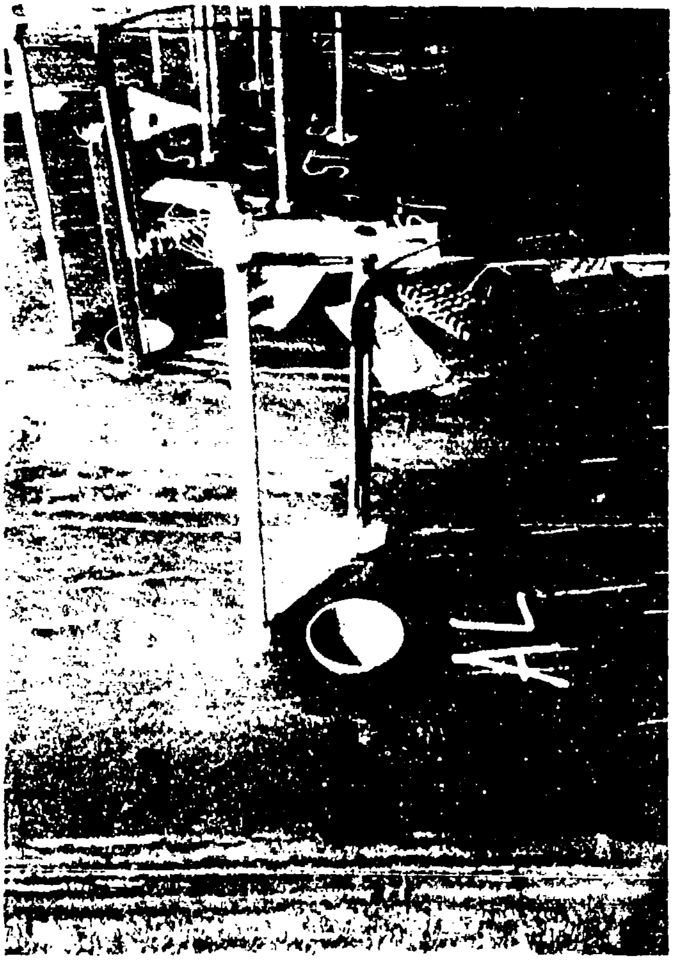


Figure 6. Shorting Pin Setup for Plug Velocity Measurement.

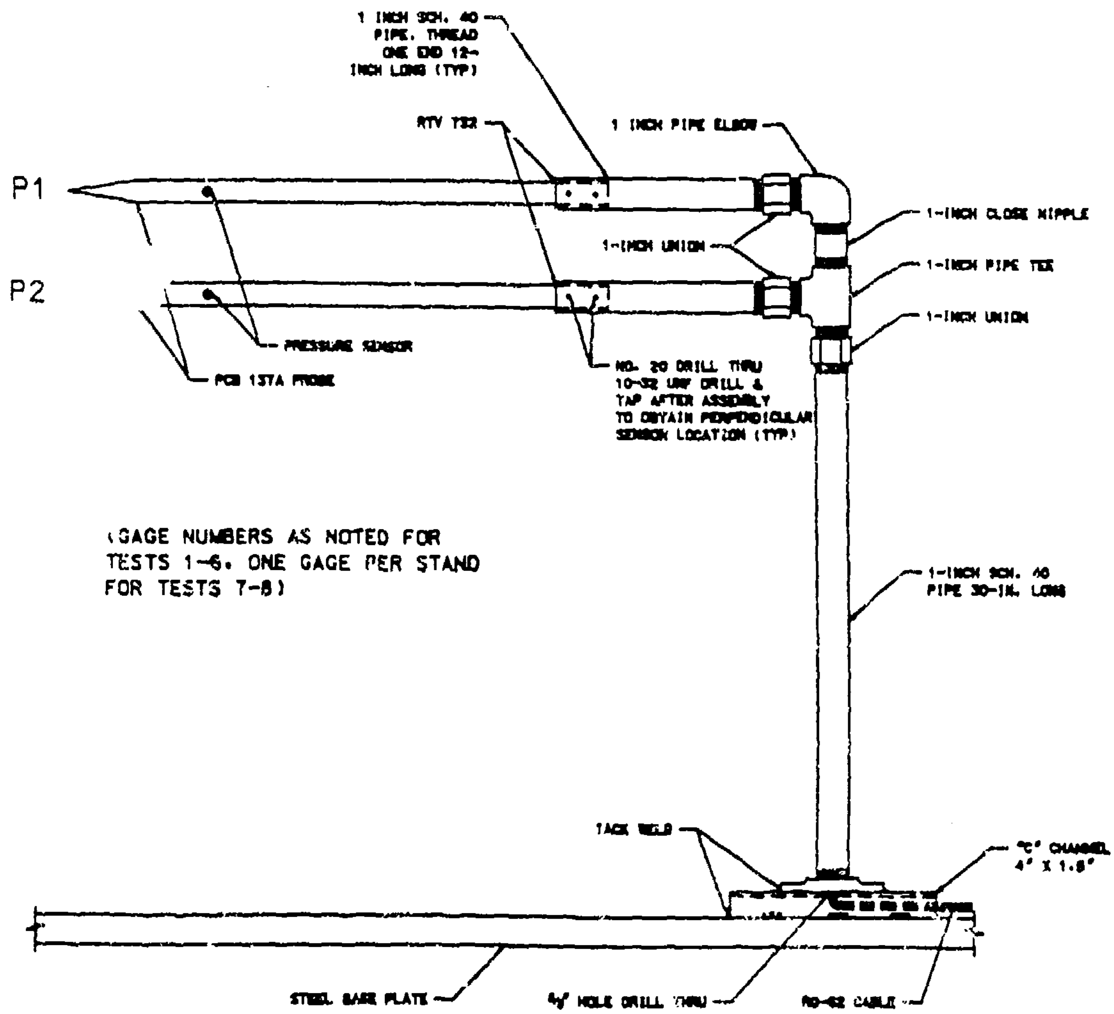


Figure 7. Side-on Pressure Gage Setup.

floor and at a standoff of 18 inches from the impulse plug fixture. Detailed descriptions of the results of each of the tests are provided in Section III of this report.

b. Instrumentation

The bare charge tests were performed, using a full complement of instrumentation, including Dynasen position transducers for measuring the impulse plug velocities (eight sets of two position transducers), PCB 137A side-on pressure gages (Reference 10) (two each at two standoffs), PCB 109A and Kulite HKS-375 reflected pressure gages (Reference 11) (six gages mounted on the impulse plug fixture adjacent to the plugs), and high-speed camera coverage. A Honeywell 24-channel analog tape recorder was used to record the data which were then digitized and processed using the computer resident at the range. Pressure-time histories were generated for each of the pressure transducers. Figure 8 shows a sample pressure-time history. Pressure-time histories and impulse plug velocities for each of the tests are included in Appendix A.

2. Task 1B - Tests To Establish Impulse and Peak Pressure Distributions for a Simulated Cased Charge

Loads tests with simulated cased charges were conducted for two reasons. First, it was necessary to determine the casing effect on the airblast produced by each charge, that is, the airblast reduction from energy loss in case fracture and launch. Second, that the casing fragments had to be quantified in terms of geometry, weight and velocity such that a determination of fragment impulse and impulse distribution could be made. These tests were conducted using charges simulating a heavily cased weapon and a lightly cased weapon as described in TABLE 2.

TABLE 2. PHYSICAL CHARACTERISTICS OF FULL-SCALE AND MODEL BOMBS.

	Mk 82 (Reference 1) GP 500 pound Bomb		AN-Mk 1 AP 1600 pound	
Scale	Full	1:4.3	Full	1:4.3
Explosive Type	H-6	C4	TNT	C4
Explosive Wt. (pounds)	192.0	2.707	215.0	2.395
Equivalent Wt. TNT	243.0	3.0	215.0	2.7
Case Diameter (inches)	10.8	2.51	14.0	3.256
Case Thickness (inches)	0.3	0.0697	1.3	0.302

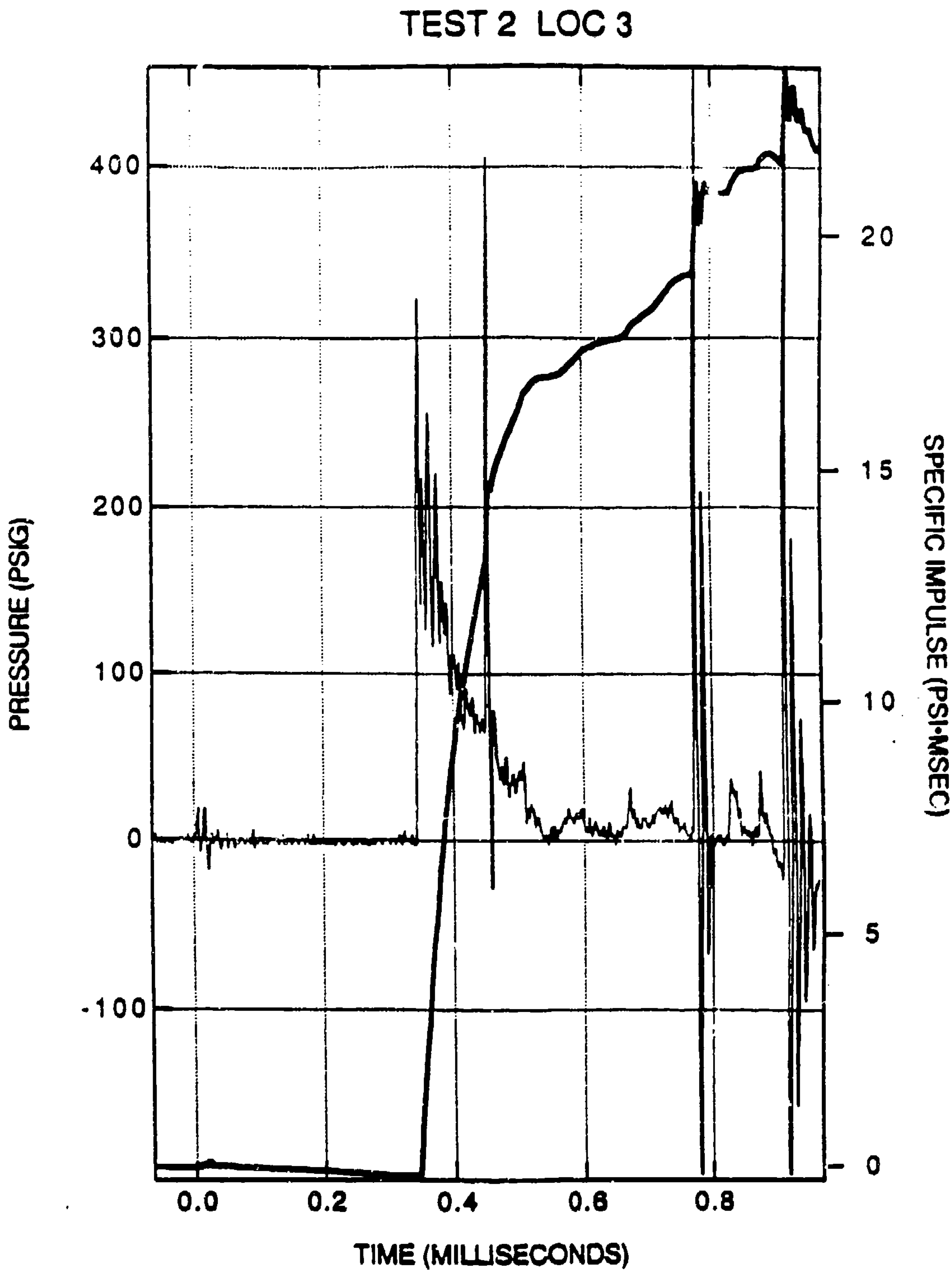


Figure 8. Sample Pressure - Time History Recorded During Testing.

a. Test Description

The scaled cased charge tests were also conducted in the reinforced concrete culvert. A total of three tests were conducted. Two tests were conducted using the 2.4-pound cased charge and one test used the 2.7-pound cased charge. All three tests were conducted with the center of the cased charge positioned 36 inches above the floor and at a standoff of 18 inches from the impulse plug fixture. Detailed descriptions of each test are provided in Section III of this report.

A network of velocity break screens was located outside of the west end of the culvert (Figure 9) to measure maximum casing fragment velocities. Fiberboard bundles were placed behind the velocity screens to capture the actual fragments thereby providing data on fragment size and depth of penetration. The velocity data and the measured fragment mass data were used to determine impact energy.

Pressure measurements were recorded for each of the cased tests. Side-on pressure measurements were made at two standoffs from the charge with two gages located at each standoff. The first cased tests were conducted with the side-on pressure gages located at 24 inches and 36 inches. The gages were severely damaged by the fragments in this test. It was then decided to move them further back for the remaining tests. As previously mentioned, six reflected pressure gages were located on the impulse plug fixture and measurements were made at each of these locations.

b. Instrumentation

The cased charge tests were conducted using a considerable amount of instrumentation including Dynasen position transducers for measuring the impulse plug velocities (eight sets of two position transducers), fragment break screens (eight sets of two screens), side-on pressure gages (two each at two standoffs), PCB and Kulite reflected pressure gages (six gages mounted adjacent to the impulse plugs), and high-speed camera coverage. SwRI utilized a 24-channel Honeywell analog tape recorder to record the impulse plug velocity data and the pressure data. The fragment break screen data were recorded using eight sets of counters. The analog data were digitized and processed and pressure-time histories were generated for each pressure transducer. Pressure-time histories as well as individual impulse plug velocities are provided for each test in Appendix B.

C. TASK 2 - TESTS FOR PANEL RESPONSE MODE INITIATION STANDOFF - CASED AND BARE CHARGE TESTS

Tests of the three types of walls were conducted to evaluate the effectiveness of the lightly cased, heavily cased and

corresponding equivalent bare explosive charges. The tests were designed to produce breach or near breach responses in each of the panels. The result of these tests allowed comparisons with existing predictive models to be made. Additionally, the results provide quantification of the synergism or nonimpulse-related local material failure effects for cased charges.

A unique aspect of these tests was the use of the Dynasen carbon stress gages to measure internal stresses in each of the panel types subjected to all three charge types (lightly cased, heavily cased and bare equivalent). Use of the gages proved successful.

1. Panel Fabrication

Three types of panels were tested using the cased and the equivalent bare charges. Equivalent bare charges were developed based on the analysis of data generated from the tests described in the previous section. Description of that analysis is provided in Section III. Two of the panel types were reinforced concrete panels and the third panel was a Slurry Infiltrated Fiber CONcrete panel (SIFCON) with a centerline steel reinforcement mat. Standard concrete batch designs were used in the R/C panel fabrication with the maximum size aggregate used being 1/4 inch. Compressive cylinder or cube tests were performed on all cement materials. TABLE 3 presents slurry strength data (SIFCON panels), mortar cube strength data (mortar used in carbon gage placement), and cylinder strength data. The steel selected for use in all three panel designs had a yield strength of 65 KSI, an ultimate strength of 95 KSI and was supplied in the form of mats welded at each intersection. Four panels were fabricated for each panel type and all fabrication was done at SwRI. The following paragraphs describe the fabrication procedures for the three wall types.

The first type of panel, Type A (Figure 10), was a standard reinforced concrete panel 50 inches high by 68 inches wide by 4 inches thick. The reinforcement used consisted of two 8 gage steel mats having a 3-inch by 3-inch spacing resulting in a reinforcement ratio of 0.20 percent. The steel mats were spaced 3 inches apart using 17-gage wire stirrups as shown in Figure 11, allowing for a 0.5-inch cover on both faces. Twelve mounting holes (six per side) were provided for attaching the wall to the test structure. A schematic identifying the pertinent construction details is provided here as Figure 11.

The second type of panel, Type B, was also a standard reinforced concrete panel 50 inches high by 68 inches wide by 4 inches. This design, however, had a percentage of steel of 0.91 percent steel each face each way. The type B wall used two three gage mats having a 1.5-inch by 1.5-inch spacing. The mats were

also spaced 3 inches apart, using the 17-gage stirrups as shown in Figure 12, giving the wall a 0.5-inch cover on each face. Construction details for this wall type are given in Figure 13.

The third type of panel, Type C, was a reinforced SIFCON panel. This design was also 50 inches high and 68 inches wide and 4 inches thick. The type C wall consisted of a slurry mix with Dramix 30/.050 fibers at a volume percentage of 10 percent with a single 13 gage mat with 3 inch by 3 inch spacing centered in the middle of the wall (0.1 percent reinforcement ratio) as shown in Figure 14. The fabrication of the SIFCON panels required that the fibers be freely dispersed into the form to prevent balling, thereby allowing a maximum percentage of fibers to be added to the form. From past experience, it was found that any attempt to increase the percentage of fibers by vibrating the fibers or by trying to pack the fibers down resulted in some of the fibers being oriented in a vertical position creating small pockets of fibers. These pockets occupied a much larger volume of the form and resulted in an actual reduction in the percentage of fibers that could be cast into the panel. Once the fibers and reinforcement were in place, the slurry was slowly poured into the form and lightly tamped to insure a uniform fill. This is shown in Figure 16. Details of Panel-Type C are shown in Figure 15. Slurry placement is shown in Figure 16.

2. Test Description

The panel-response mode tests were performed inside of the reinforced concrete containment structure. Two steel angles having the same hole pattern as the test panels were welded to the containment structure walls. Two channel sections also having the same hole pattern were used to clamp the wall panels to the containment structure as shown in Figure 17. The cased and the equivalent bare charges were centered vertically in front of the test wall at a height of 25 inches from the floor of the containment structure and at a specified standoff. The cased charge tests and the 2.4-pound equivalent charge tests were conducted at a standoff of 6 inches from the test panels. The 2.8-pound equivalent tests were conducted at a standoff of 7 inches from the test panels. All of the cased charge tests utilized casings fabricated identical to the casings tested in Task 1B.

3. Instrumentation

All four of the Type B panels and two of the Type C panels were instrumented with Dynasen piezoresistive shock pressure carbon gages (References 9, 13, 14) and with piezocrystals for measuring the time-of-arrival of the shock wave as it moved through the wall panel. Four of the carbon shock pressure gages were installed in each of the test walls at two different depths, 0.5 inches and 3.5 inches from the surface of the panel exposed to the charge. The

TABLE 3. CONCRETE AND SLURRY STRENGTH DATA.

SIFCON 2 inch x 2 inch Slurry Cubes	Age (Days)	Compressive Strength (psi)	Average Compressive Strength (psi)
1A	7	8,965	
2A	7	7,335	8,560
3A	7	9,380	
1B	14	8,700	
2B	14	9,270	9,100
3B	14	9,335	
1C	28	9,450	
2C	28	8,920	9,090
3C	28	8,905	
4 inch x 8 inch Concrete Cylinders			
1A	7	4,935	
2A	7	4,775	4,930
3A	7	5,090	
1B	14	5,490	
2B	14	5,330	5,490
3B	14	5,650	
1C	28	5,965	
2C	28	5,810	5,965
3C	28	6,125	
4A	60	5,650	
4B	60	6,050	5,890
4C	60	5,970	
Gage Placement Mortar Cubes			
1M	14	4,800	
2M	14	4,700	4,797
3M	14	4,890	

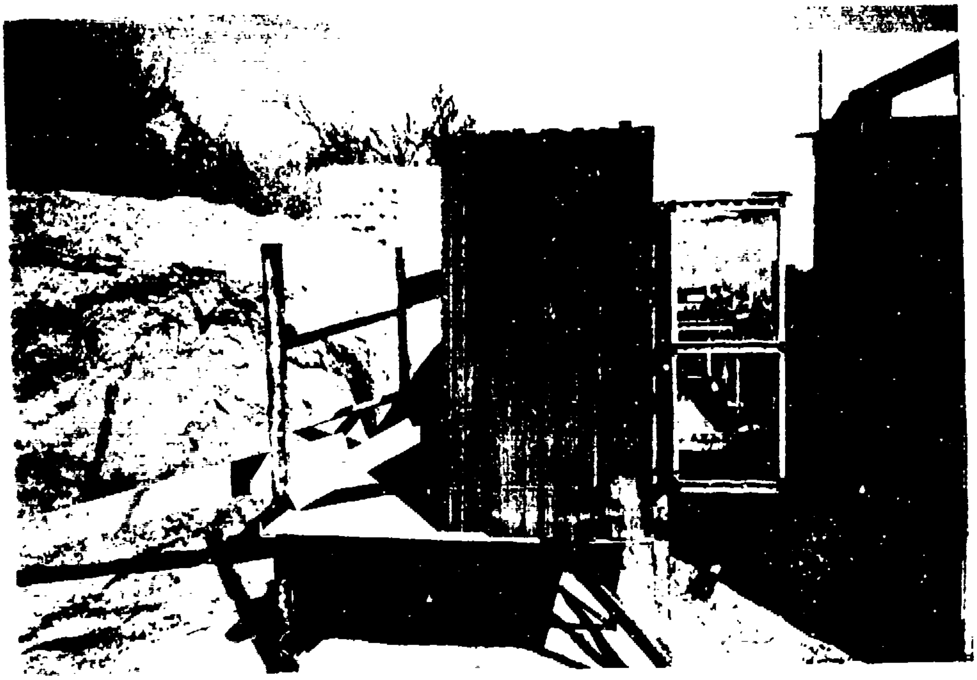


Figure 9. Velocity Screen and Fiberboard Bundle Setup for Cased Charge Tests.

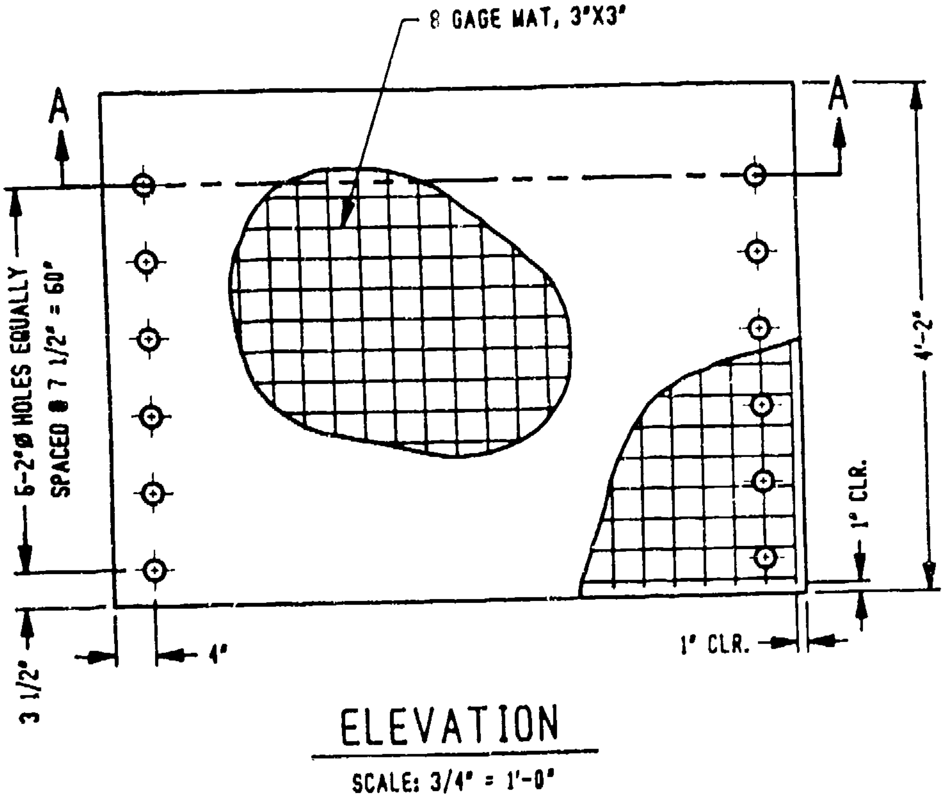
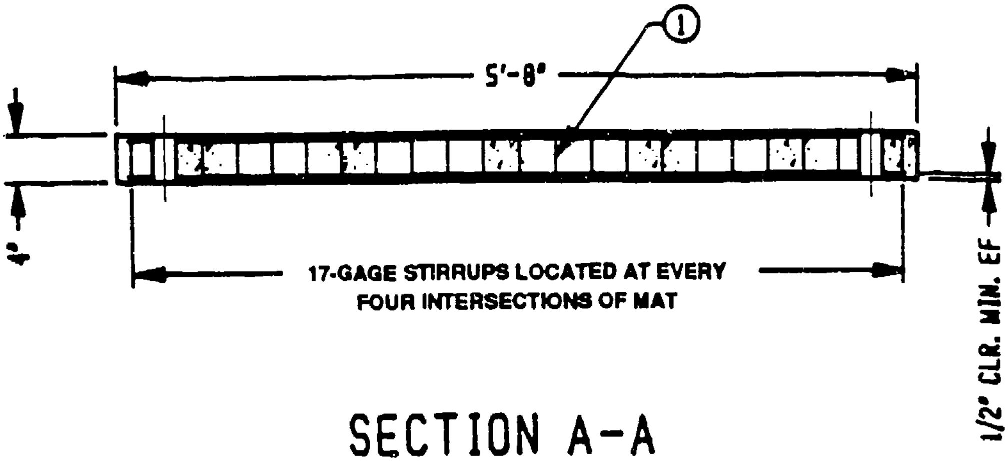
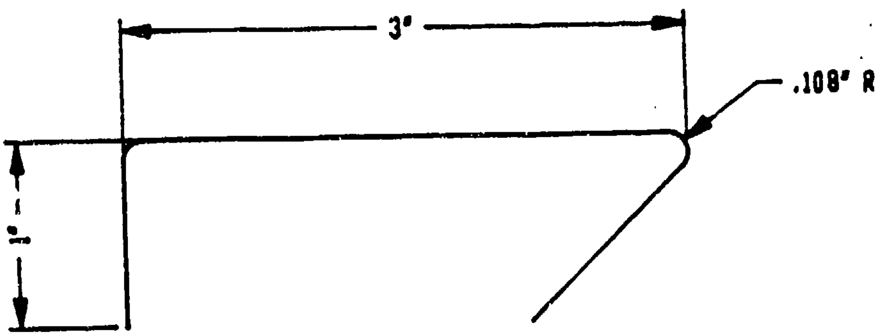


Figure 10. Panel-Type A Layout.



SECTION A-A

SCALE: 3/4" = 1'-0"



NOTE: 135° HOOK STIRRUP, 17 GAGE WIRE

DETAIL 1

SCALE: 12" = 12"

Figure 11. Panel-Type A Details.

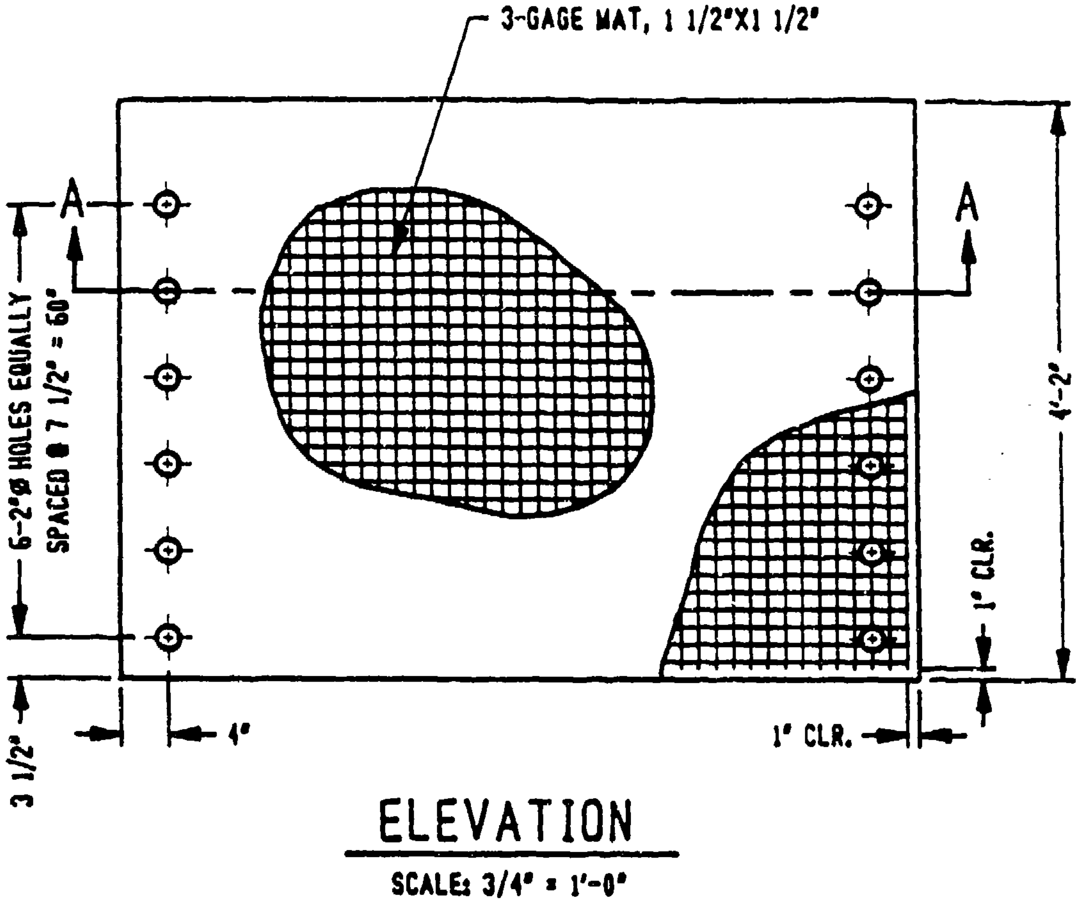
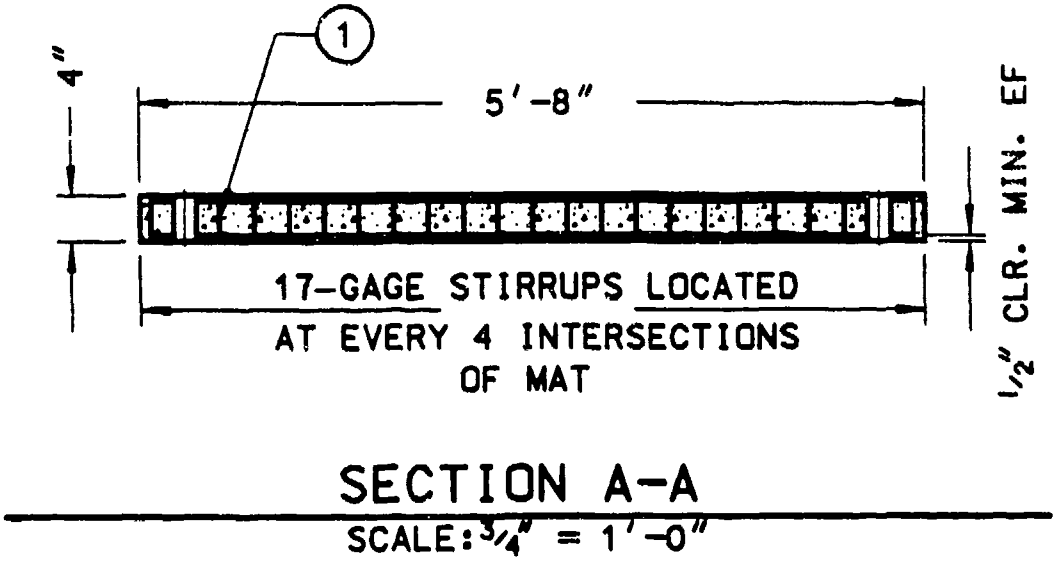


Figure 12. Panel-Type B Layout.



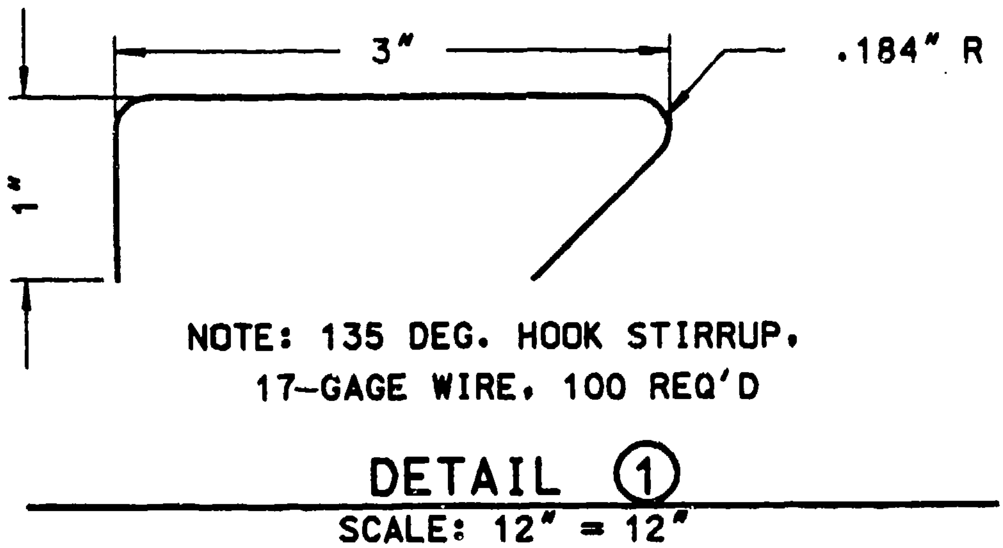
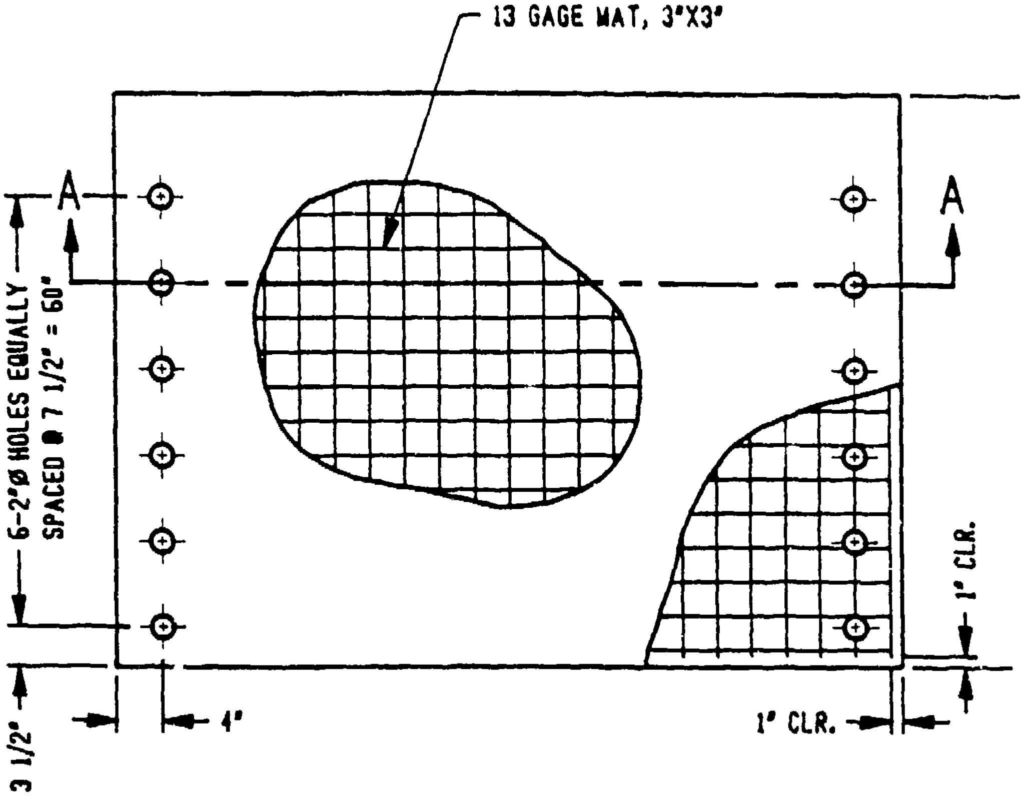
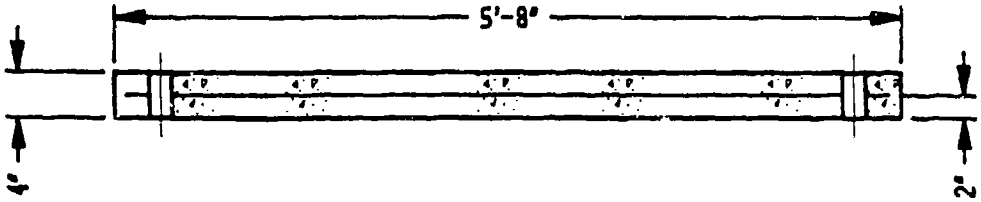


Figure 13. Panel-Type B Details.



ELEVATION

SCALE: 3/4" = 1'-0"



SECTION A-A

SCALE: 3/4" = 1'-0"

Figure 14. Panel-Type C Layout.

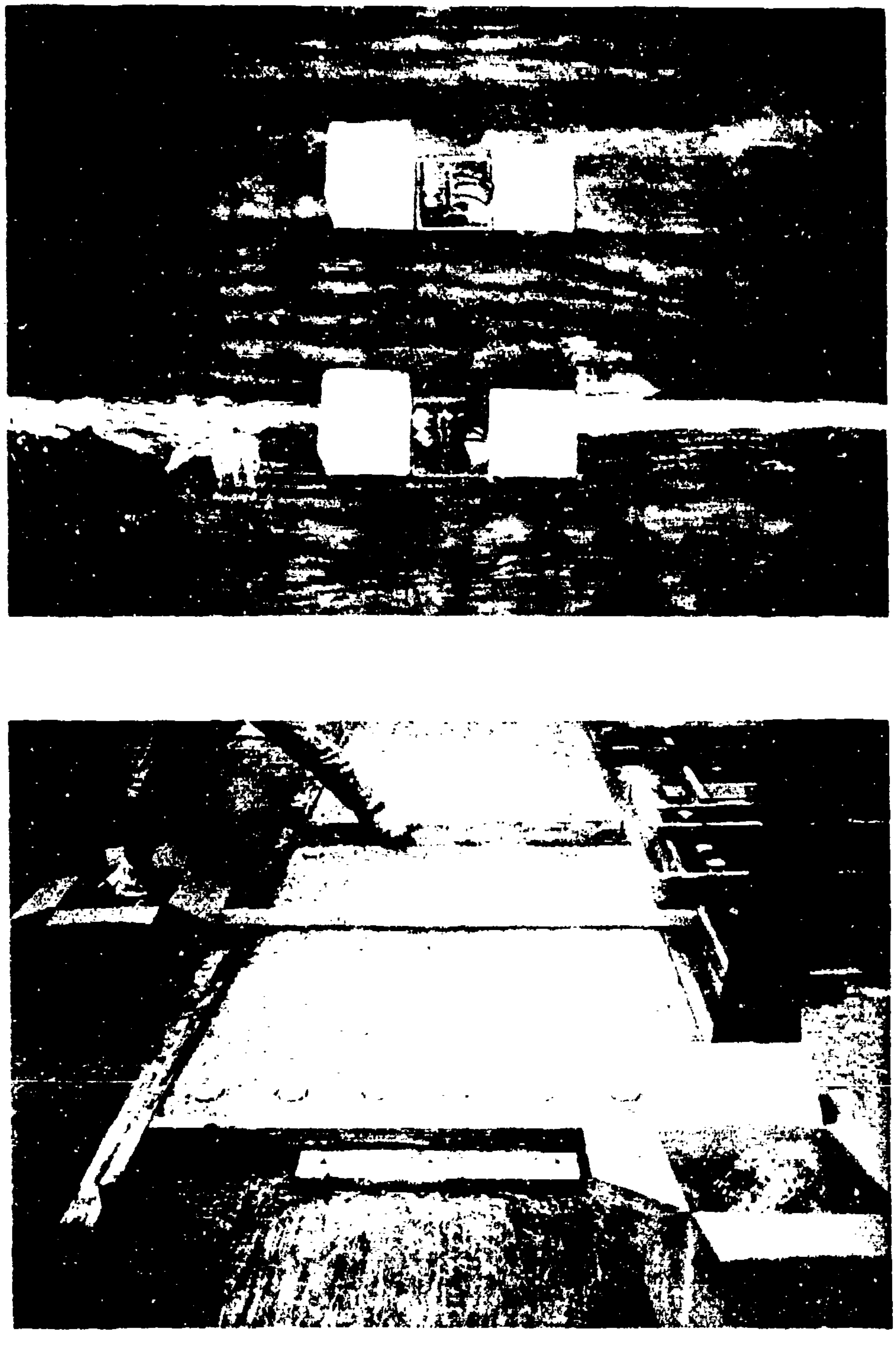


Figure 15. Panel-Type C Details.

Figure 16. Panel Fabrication.

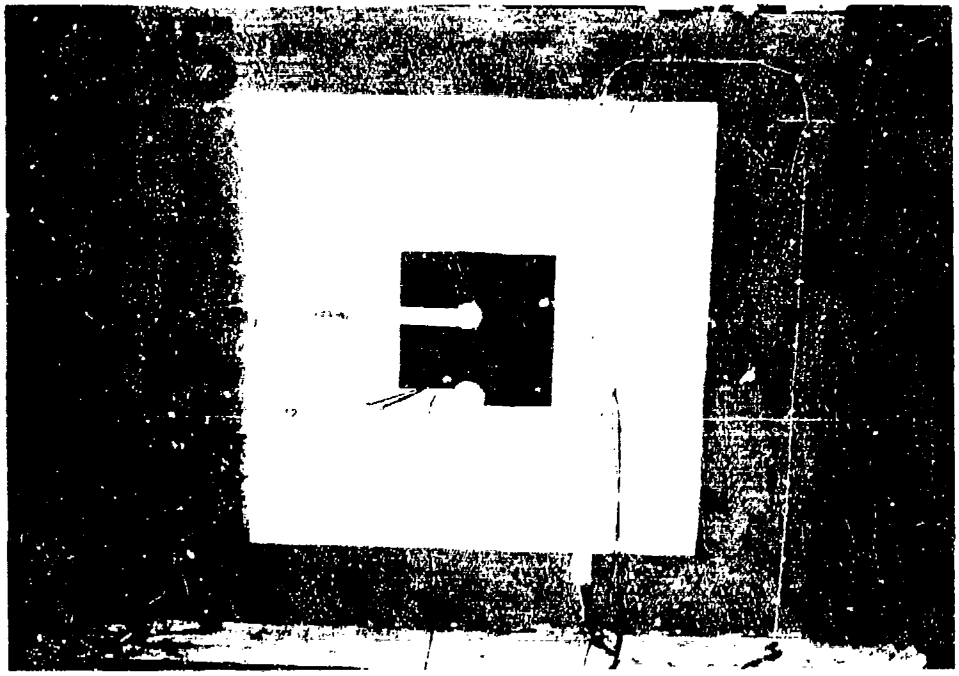


Figure 17. Panel Support.

piezocrystals were installed in the test panels in two arrays of four crystals per array. The crystals in each array were 0.5 inches apart with the crystal being located 0.5 inches below the surface of th ete closest to the charge. The exact locations of the gages shown in Figure 18 for the Type B panels and in Figure 19 for the Type C panels. Details of the gage placement are shown in Figure 20. The outputs of the carbon shock pressure gages and of the crystals were recorded on magnetic tape and were subsequently analyzed. Computer-generated plots of these outputs were made and are included in Appendix C of this report.

Calibration of the Dynasen carbon pressure gage was accomplished through a simulation of the behavior of the gage under pressure. Since the percentage change in resistance of the carbon element under pressure is known, we can simply insert that calculated resistance can be used to obtain the voltage output for that pressure.

The Dynasen pulse power supply provides a relatively short-duration excitation voltage to the gage and the associated bridge arrangement. The voltage can be adjusted from 30-300 VDC and the duration can be adjusted from 5 microseconds to hundreds of microseconds. It was determined that a duration of about 500 microseconds was needed to allow ample time for data recording. The power supply schematic is shown in Figure 21.

To select a suitable excitation voltage, an actual carbon gage with its connecting cable was connected to the power supply after the pulse duration was set to 500 microseconds. Beginning at 30 volts, the gage was pulsed and the output monitored to check for both gage heating and for an appropriate output level to allow recording throughout the 2 - 7-kilobar region. Voltage levels above 50 volts caused gage heating due to the relatively long pulse time (500 microseconds), thus a 50-volt level was selected.

Next, a standardized bridge output attenuation setting was needed in order to ensure that the calibrations remained accurate when gages were replaced between tests and different pressure levels were expected. By simulating both extremes of pressure, a 0 attenuation was found to be both suitable and convenient because the potentiometer is simply turned against its stop and the bridge output would not be high enough to saturate the buffer/follower output stage.

To perform the actual calibration, the gage resistance was added to the cable resistance and the negative change in gage resistance corresponding to the pressure level ($\Delta R/R$) was calculated and subtracted from the total. The $\Delta R/R$ as provided by Dynasen is shown in Figure 22. A decade resistor with .01 ohm resolution was used to provide this calculated resistance. The power supply was then pulsed and a Nicolet digital oscilloscope was used to measure the voltage output over the 500 microsecond pulse. Sixteen pressure

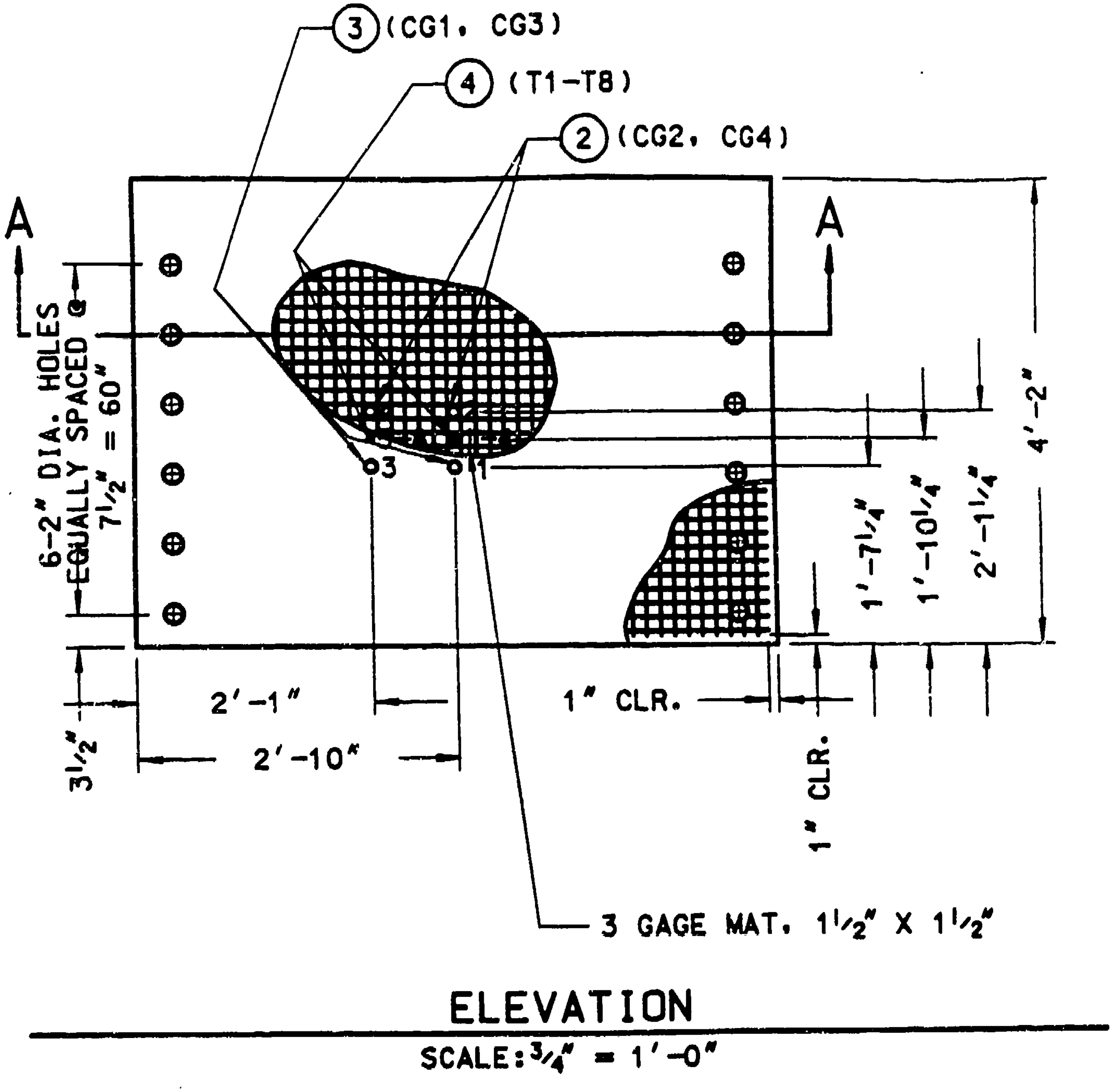


Figure 18. Panel-Type B Carbon Gage and Piezocrystal Locations.

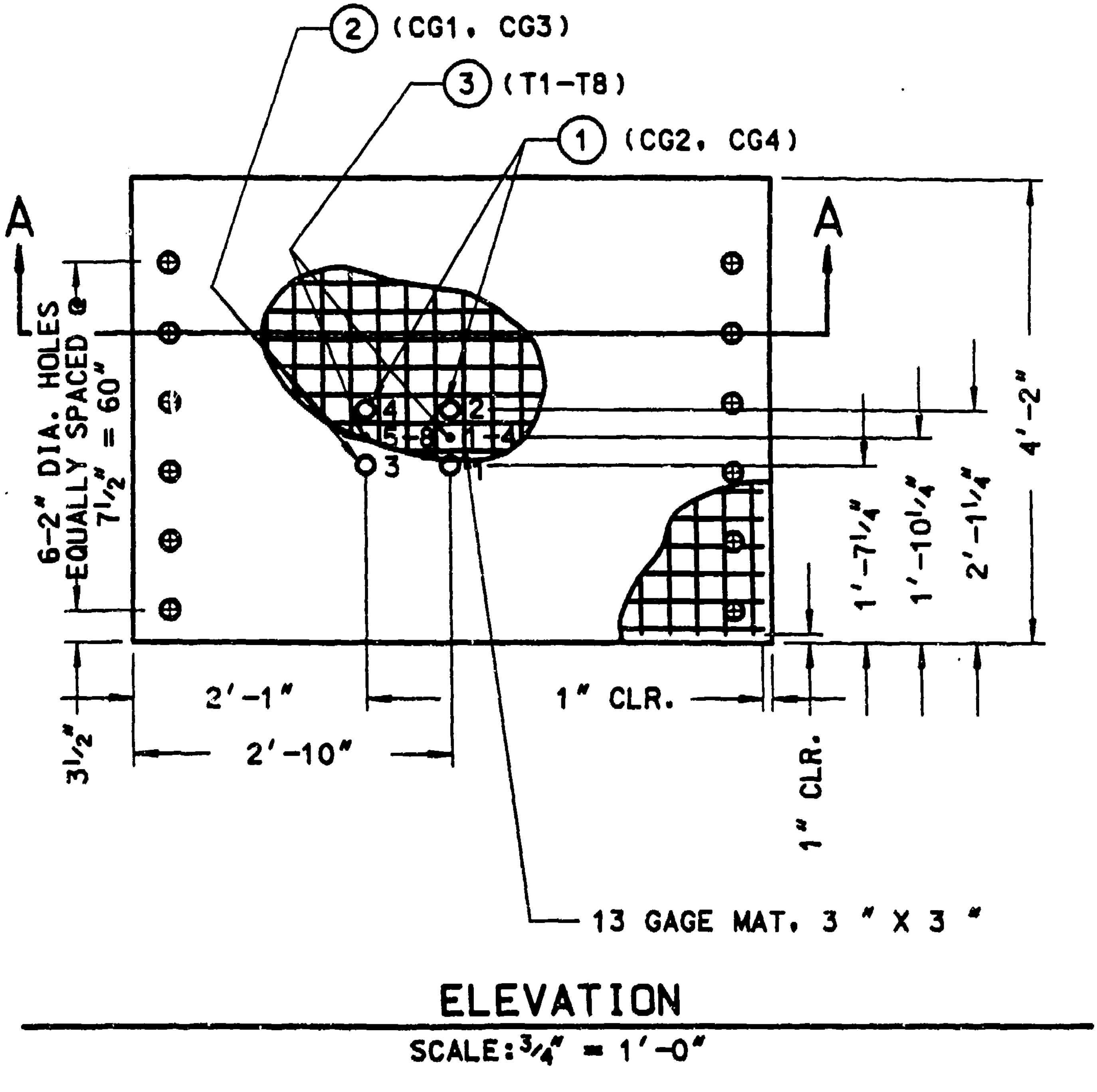


Figure 19. Panel-Type C Carbon Gage and Piezocrystal Layout.

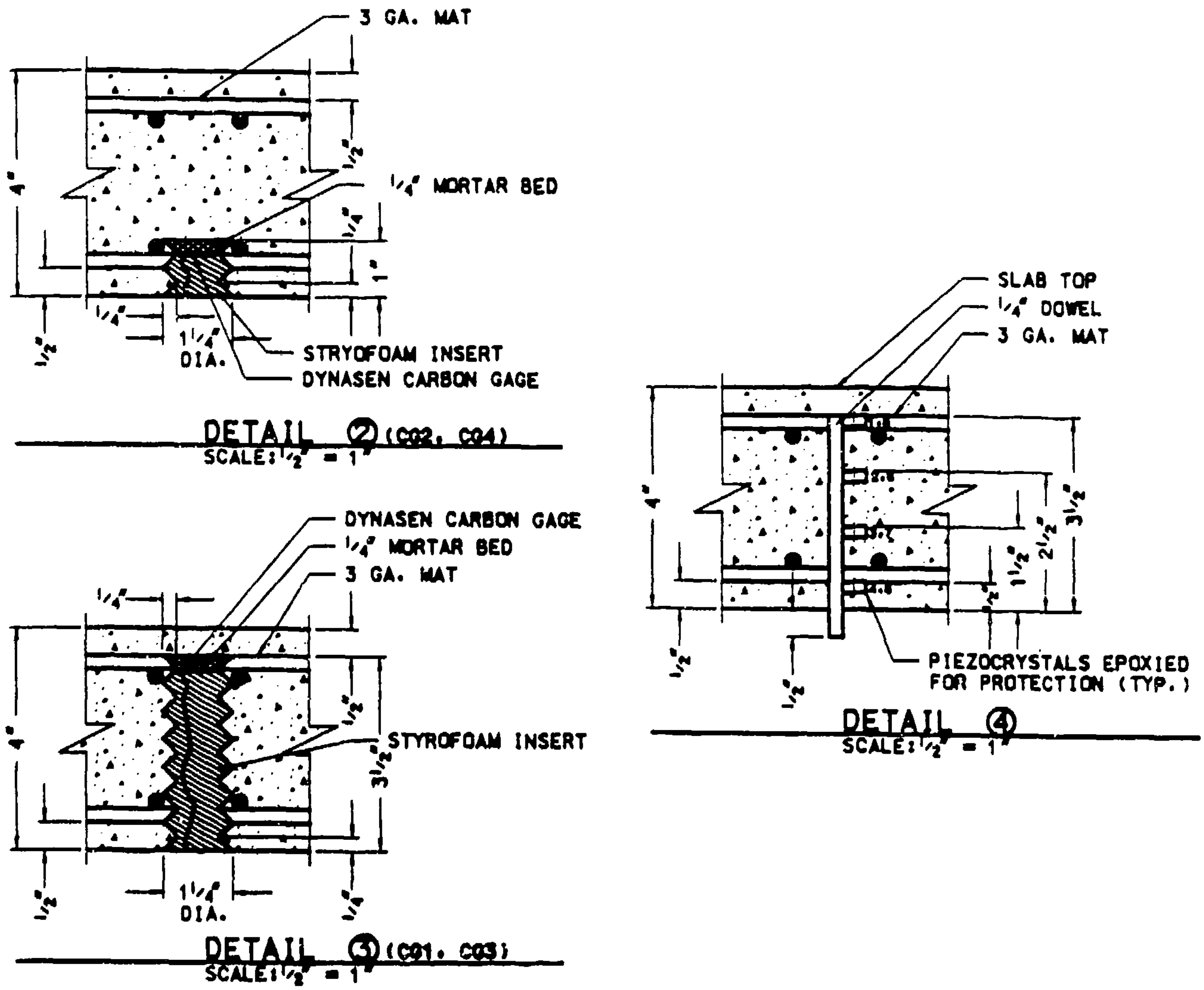


Figure 20. Details of Gage Placement for Panel-Types B & C.

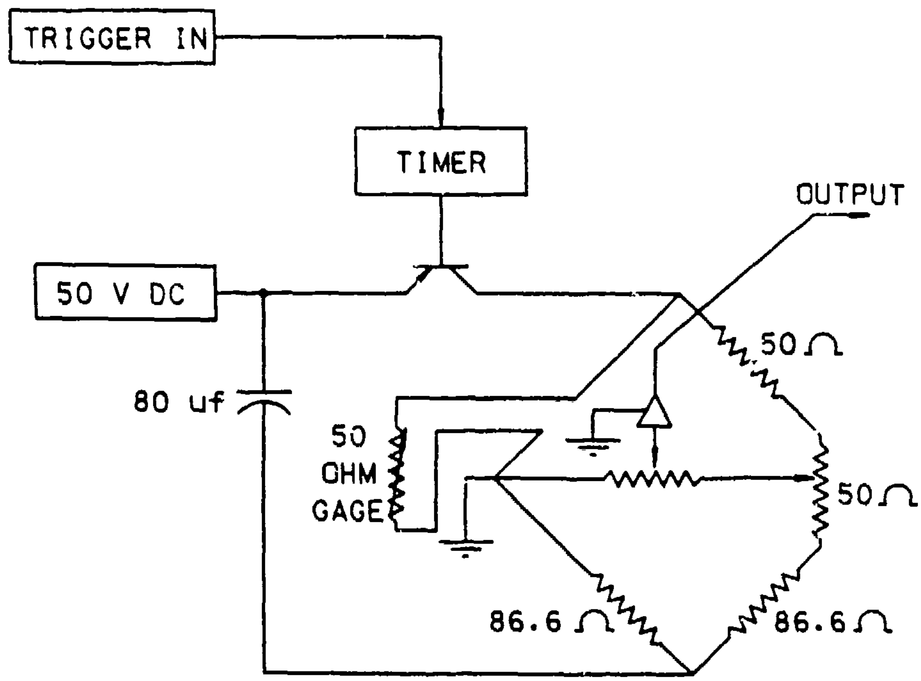


Figure 21. Carbon Gage Power Supply Schematic.

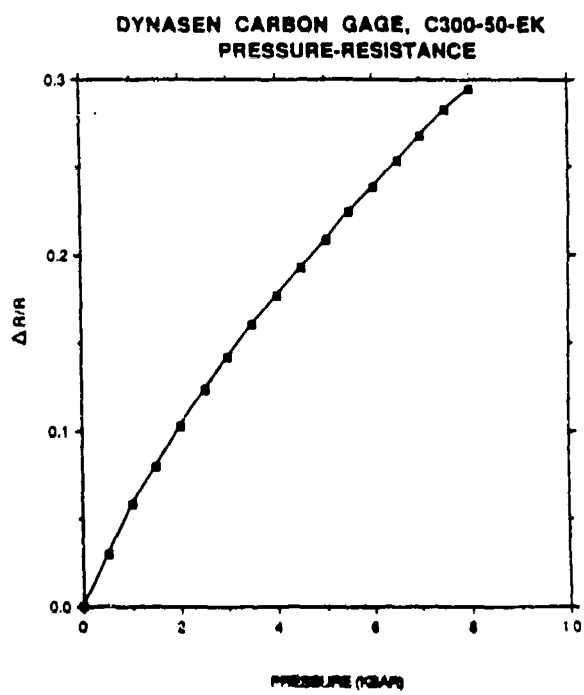


Figure 22. Carbon Gage Sensitivity ($\delta R/R$).

points from 0 - 7.5-kilobars were then read in the same manner. A typical calibration curve is shown in Figure 23. All calibrations are included in Appendix D.

Since the carbon gages provided by Dynasen ranged in resistance from 48-55 ohms, calibrations were performed in four resistance ranges; 48, 50, 52, and 54 ohms. Also, all four gage resistance range calibrations were performed on each of the four channels of pulse power supplies used so that any gage could be connected to any power supply and an accurate calibration would exist.

High-speed cameras were also used to document the tests. One camera was positioned so that it viewed the back side of the panel to observe the wall failure mechanism. The back sides of the walls were painted to aid in viewing the failure mechanism. A second high-speed camera was positioned perpendicular to the side of the reaction structure, that is, perpendicular to the trajectory of the resultant wall back face fragments. A grid background was positioned next to the far side of the reaction structure as shown in Figure 24 and was used to determine the velocity of the fragments.

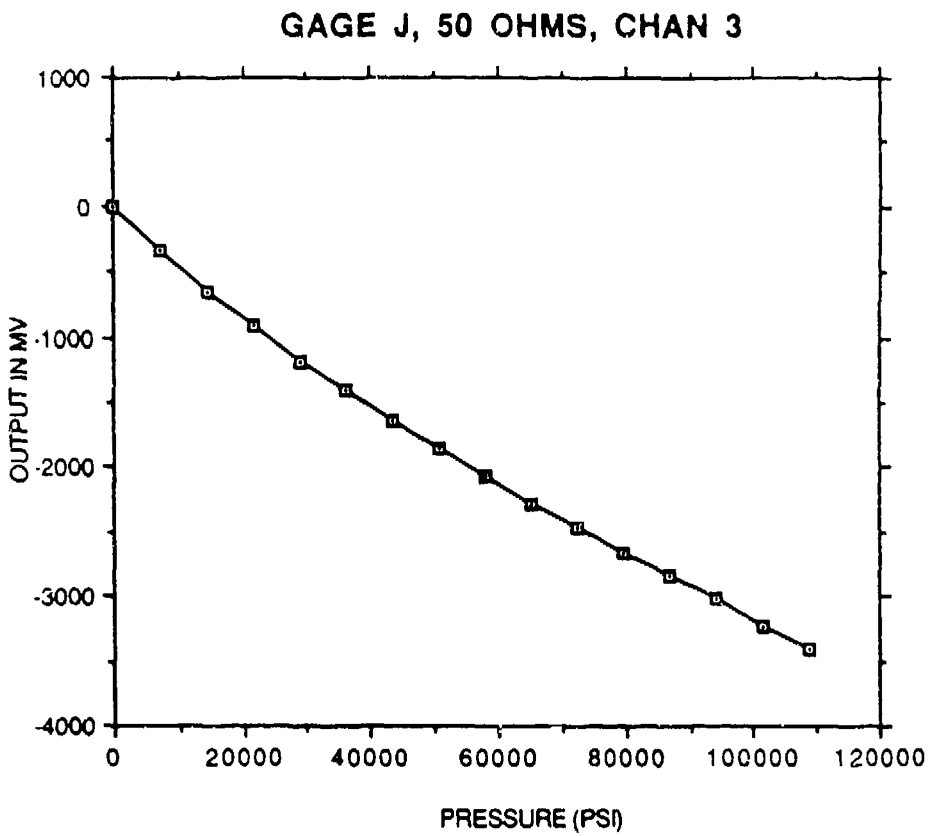


Figure 23. A Typical Carbon Gage Calibration Curve.

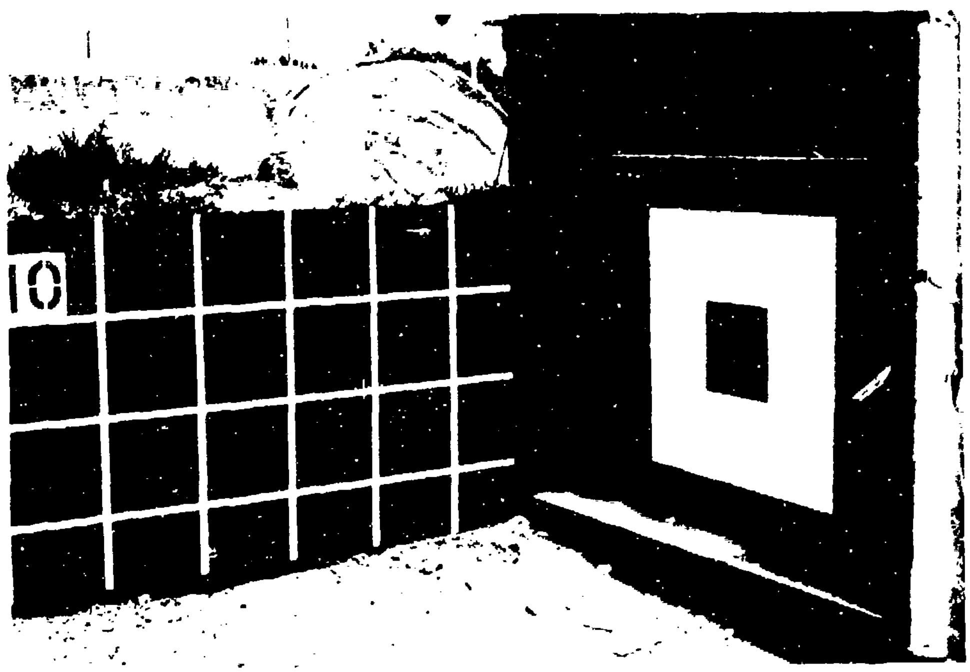


Figure 24. High-speed Camera Grid.

SECTION III. TEST RESULTS

A. LOADS TESTS

1. Bare Charge Tests

The bare charge tests were conducted inside of the reinforced concrete structure as previously described. A total of 5 tests were conducted using the bare charges, three tests with the 2.4-pound charge and 2 tests with the 2.7-pound charge. The 2.4-pound charges were cylindrical in shape having a diameter of 2.65 inches and a length of 7.54 inches The 2.7-pound charges were also cylindrical having a diameter of 2.372 inches and a length of 10.7 inches In all of the bare charge tests, the center of the charge was located at a height of 36 inches from the bottom of the floor and at a standoff of 18 inches from the impulse plug plate. The following paragraphs describe the tests.

a. Test 1

The first test conducted involved a bare C4 charge weighing 2.4-pounds. This test was instrumented with five reflected pressure gages mounted at positions P6-P10 and four side-on pressure gages, P1-P4. The side-on gages were located at 24 inches and 36 inches as shown in Figure 25. Eight impulse plugs with aluminum caps were used in this test with eight sets of fiber-optic break wires to measure the plug velocities. Two fiber-optic cables spaced 6 inches apart were placed on the back face of the impulse plug fixture directly behind each of the impulse plugs. As the impulse plugs were loaded by the blast and were driven out of the fixture, the plug severed each of the two cables. A time pulse was provided by each cable when the impulse plug broke the cable. The break times and the distances between cables were used to calculate the plug velocity. Six of the eight impulse plugs were completely driven out of the fixture. Plug 7 did not exit the fixture at a high enough velocity to break the second fiber-optics cable and a velocity was not obtained for this particular plug. A velocity was also not obtained for Plug 8 due to instrumentation problems. Pressures were measured by each of the four side-on gages and by four of the five reflected pressure gages. The computer generated pressure-time history for Gage P6 showed that the gage was damaged during the test and a peak pressure was not measured. TABLE 4 summarizes the peak pressures measured by the remaining gages. TABLE 5 provides maximum impulses resulting from integration of those records. TABLE 6 presents the impulse plug velocities, and TABLE 7 presents the calculated impulses based on plug mass. Original data sheets are included in Appendix A.

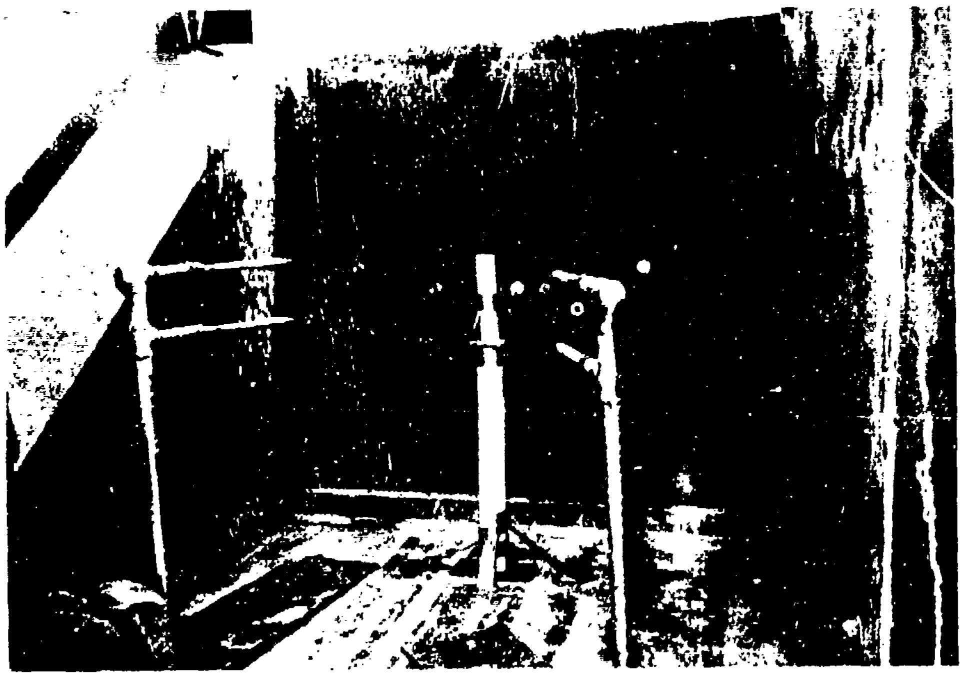


Figure 25. Side-on Gage and Charge Placement for Test 1.

TABLE 4. COMPARISON OF PRESSURES FOR BARE CHARGE TESTS.

Gage Location	Measured Pressures (psi)				
	Test 1 (2.4)	Test 2 (2.7)	Test 3 (2.4)	Test 4 (2.7)	Test 5 (2.4)
P1:	528	464	625	325	512
P2:	891	1280	1100	660	950
P3:	175	324	600	315	N/A
P4:	575	741	375	399	N/A
P5:	N/A	N/A	N/A	N/A	GF
P6:	GF	N/A	N/A	N/A	GF
P7:	800	N/A	900	GF	GF
P8:	9250	GF	GF	5586	7441
P9:	2100	2690	2400	2600	977
P10:	24000	14000	GF	16296	21780
P11:	N/A	6956	4500	GF	7916
P12:	N/A	4656	3000	3500	2654

TABLE 5. COMPARISON OF IMPULSES FOR BARE CHARGE TESTS.

Gage Location	Integrated Impulses (psi-msec)				
	Test 1 (2.4)	Test 2 (2.7)	Test 3 (2.4)	Test 4 (2.7)	Test 5 (2.4)
I1:	22.6	16.6	21.4	20	27
I2:	29	30.7	24.4	46.9	39
I3:	19	17.8	43	25	N/A
I4:	35	45	23	40	N/A
I5:	N/A	N/A	N/A	N/A	GF
I6:	GF	N/A	N/A	N/A	GF
I7:	200	N/A	98.8	GF	GF
I8:	160	GF	GF	126.9	241
I9:	114	140	78	150	93.5
I10:	430	GF	GF	336	290
I11:	N/A	310	263	GF	353
I12:	N/A	272	170	200	171

TABLE 6. COMPARISON OF IMPULSE PLUG VELOCITIES FOR BARE CHARGE TESTS.

Plug No.	Measured Velocity (fps)				
	Test 1 (2.4)	Test 2 (2.7)	Test 3 (2.4)	Test 4 (2.7)	Test 5 (2.4)
1:	28.5	37.8	38.4	30.9	30
2:	53.4	59.4	39.2	41.9	N/A
3:	69.4	43.9	42.6	47.6	31.7
4:	111.8	42.8	53.4	60.5	42.8
5:	90.8	38.9	61.2	56.9	43.8
6:	N/A	39.9	30.5	42.2	27.4
7:	N/A	40.5	38.5	44.1	42.4
8:	N/A	N/A	38.7	23.9	32.9

TABLE 7. COMPARISON OF CALCULATED PLUG IMPULSES FOR BARE CHARGE TESTS.

Plug No.	Calculated Impulse[1] (psi- msec)				
	Test 1[2] (2.4)	Test 2[3] (2.7)	Test 3[4] (2.4)	Test 4[4] (2.7)	Test 5[4] (2.4)
1:	147.0	195.0	198.1	159.4	154.8
2:	275.5	306.5	388.9	415.7	N/A
3:	358.1	435.6	422.7	472.3	314.5
4:	576.8	424.7	529.8	600.3	424.7
5:	468.5	386.0	607.2	555.6	434.6
6:	N/A	395.9	302.6	418.7	271.9
7:	N/A	209.0	198.6	227.5	218.8
8:	N/A	N/A	199.7	123.3	169.7

Notes:
1) Plug face area = .13 inches^2
2) All plugs were aluminum. The average plug weight was 0.52 pounds
3) Plugs 1,2,7 and 8 were aluminum. Plugs 3-6 were steel with a weight of 1 pound
4) Plugs 1,7 and 8 were aluminum. Plugs 2-6 were steel.

b. Test 2

The second test conducted involved a bare charge weighing 2.7-pounds. This test was also instrumented with four side-on pressure gages (P1-P4) and five reflected pressure gages (P8-P12). The side-on gages were again located at 24 inches and 36 inches. Eight impulse plugs were used on this test. Five plugs had steel caps and three plugs had aluminum caps. This test also used sets of two fiber-optic break wires for each impulse plug for measuring the plug velocities. Seven of the eight impulse plugs were completely driven out of the fixture. Plug 8 did not break the second fiber-optics cable and a velocity was not obtained for this plug. Pressures were measured by each of the four side-on gages and by four of the five reflected pressure gages. These data are provided in TABLE 4. TABLE 5 presents the impulses measured and TABLES 6 and 7 include measured plug velocities and calculated specific impulse. The review of the pressure-time histories showed that gage no. P8 failed during the test and did not accurately measure the peak reflected pressure. Gage P10 was also damaged during the test, however, a peak reflected pressure was measured before the gage failed. The computer generated pressure-time histories, the impulses and the fiber-optics break times are given in Appendix A of this report.

c. Test 3

The third test conducted involved a bare charge weighing 2.4-pounds. This test was instrumented with six reflected pressure gages located at positions P7 - P12 and with four side-on pressure gages, P1-P4. The side-on gages were located at 24 inches and 36 inches Eight impulse plugs, five with steel caps and three with aluminum caps were used on this test. This test used the Dynasen position transducers (shorting pins) located at the back of the impulse plug fixture to measure the plug velocities. As previously mentioned, the position transducers were used in sets of two transducers, one 7 inches long and the other 6 inches long. The two transducers were located behind each of the plugs and as the plug cleared the fixture, it made contact with each transducer. All eight of the impulse plugs were completely driven out of the fixture. Velocities were calculated for each of the plugs based on the position transducer (shorting pin) data. The velocities are provided in the summary data sheet, TABLE 5. Pressures were measured by each of the four side-on gages and by four of the six reflected pressure gages. Gages P8 and P10 failed during the test, prior to measuring the peak reflected pressures. The measured pressures for the other gages are included in TABLE 4. TABLES 6 and 7 present measured plug velocity and calculated impulse. The computer generated pressure-time histories and the shorting pin times are given in Appendix A.

d. Test 4

This test involved a bare charge weighing 2.7-pounds. This test was also instrumented with six reflected pressure gages located at positions P7-P12 and with the four side-on pressure gages, P1-P4. For this test, however, the side-on gages were located at 36 inches and 48 inches Eight impulse plugs, five with steel caps and three with aluminum caps were used on this test. The impulse plug velocities were calculated using the data generated by the position transducers located behind the impulse plugs. All of the impulse plugs were completely driven out of the fixture. Pressures were measured by each of the four side-on gages and by four of the six reflected pressure gages and are included in TABLE 4. The computer generated plots for the gages located at P7 and P11 indicated that the gages were damaged during the test and the pressures measured were questionable. TABLE 5 includes the measured impulses while TABLES 6 and 7 have plug velocities and impulses. The actual computer generated pressure-time histories and the position transducer break times are given in Appendix A.

e. Test 5

This test also involved a bare charge weighing 2.4-pounds. This test was instrumented with two of the side-on pressure gages at positions P1 and P2 and with eight of the reflected pressure gages mounted at positions P5-P12. The two side-on gages were both placed 36 inches from the charge. The eight impulse plugs were installed as were the position transducers. Velocities were measured for seven of the eight impulse plugs. The back shorting pin on Plug 2 did not respond, thus a velocity calculation was not possible for this plug. Pressures were measured by each of the side-on gages and by all of the reflected pressure gages. The actual pressures are provided in TABLE 4. Measured impulse is presented in TABLE 5. TABLES 6 and 7 include plug velocities and impulse. The computer generated plots for the gages located at P5, P6 and P7 indicated that the gages were damaged during the test and the pressures measured were questionable. These plots are provided in Appendix A of this report.

2. Cased Charge Tests

A total of three cased charge tests were conducted inside of the reinforced concrete structure. The first cased test conducted, Test 6, involved the 2.7-pound cased charge which simulated the Mk 82 GP 500 bomb. The remaining two tests, Tests 7 and 8, were conducted using the 2.4-pound cased charge which simulated the AN-Mk 1 AP 1600 pound bomb. Tests 6 and 7 were equipped with fragment velocity break screens for measuring the casing fragment velocities. Each set of screens consisted of a front and a rear break screen made out of aluminum foil sheets 18 inches wide by 12 inches high. The front screen and the rear screen

were spaced 12 inches apart. The corners of each of the aluminum sheets were wired to trigger boxes which produced an electrical pulse when the aluminum sheet was perforated by a fragment. The signals emitted by the front and the rear break screens were recorded on counters. Times measured were used to calculate the fragment velocity. Only velocities for the first fragment to hit the screens were recorded. Velocities for those fragments impacting the screens at a later time were not measured. The first test was conducted using one row of four sets of screens. The second test conducted used two rows of four sets of velocity screens for a total of eight velocity measurements. The screens were positioned in the expected path of the cased charge fragments with the front screen located 8-feet from the charge.

The fiberboard bundles used to capture the fragments were positioned 9-feet away from the charge and directly behind the back velocity screens as shown in Figure 26. This configuration allowed some correlation to be made between the actual fragments recovered in the fiberboard and the velocities measured by the break screens. All fragments removed from the fiberboard sheets were cleaned, sized and weighed. Initial impact positions and trajectories of the fragments were recorded for use in fragment spray distribution calculations. In the three cased charge tests conducted, the center of the cased charge was always located 36 inches from the floor and with an 18-inch standoff from the impulse plug fixture. The following paragraphs describe the three cased charge tests.

a. Test 6

Test 6 was the first cased charge test conducted. A 2.7-pound cased charge simulating the Mk 82 was tested. This test had two side-on pressure gages (P1, P2) positioned 30 inches away from the charge. A steel pipe was placed in front of the side-on gages to aid in protecting the gages from fragment impacts. This fragment stripper pipe was located sufficiently far away from the gages so as to not affect the pressure measurements. Eight reflected pressure gages were installed in the impulse plug fixture at positions P5-P12. Eight impulse plugs and corresponding position transducers were also installed in the fixture, as shown in Figure 27. Four sets of velocity screens were positioned in a row and the fiberboard was located directly behind the screens as shown in Figure 26. For this test, 96 sheets of 0.5 inch thick fiberboard were used to capture the fragments. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments severely damaged four of the reflected pressure gages and only Gages P8 - P11 measured acceptable pressure levels. The two side-on pressure gages measured the pressures even though one of the gages was severely damaged. The casing fragments also impacted the impulse plugs and deformed them. The plugs were wedged in place in the fixture and only one plug (I1) was able to exit the fixture and function the position transducers. The four sets of fragment

velocity screens each recorded a fragment velocity with the four velocities ranging between 6,098 fps and 6,906 fps. The fiberboard was examined and over 171 casing fragments were recovered. Coordinates for each fragment were recorded as well as the depth of penetration, that is, the number of sheets penetrated, and the size and weight. TABLE 8 presents the pressure data, the measured impulses, and the impulse plug velocity and impulse data. Appendix E contains fragment data collected in Test 6. Break screen data for Tests 6 - 7 is included in TABLE 9.

TABLE 8. DATA SUMMARY FOR CASED CHARGE TEST 6.

Gage Location	Measured Pressure (psi)	Integrated Impulse (psi-msec)	Measured Plug Velocity (fps)	Calculated Impulse (psi-ms)
P1:	415	29	31.5	162.5
P2:	483	34	No Data	No Data
P8:	5000	265	"	"
P9:	1400	110	"	"
P10:	18350	GF	"	"
P11:	9200	300	"	"

TABLE 9. COMPARISON OF BREAK SCREEN VELOCITIES.

Screen No.	Measured Velocity (fps)	
	Test 6 2.7 Cased	Test 7 2.4 Cased
Set 1:	6906	6250
Set 2:	6671	4167
Set 3:	6519	4386
Set 4:	6098	2976
Set 5:	N/A	6757
Set 6:	N/A	4807
Set 7:	N/A	5556
Set 8:	N/A	6097

Figure 26. Fiberboard Setup for Tests 6 - 7.

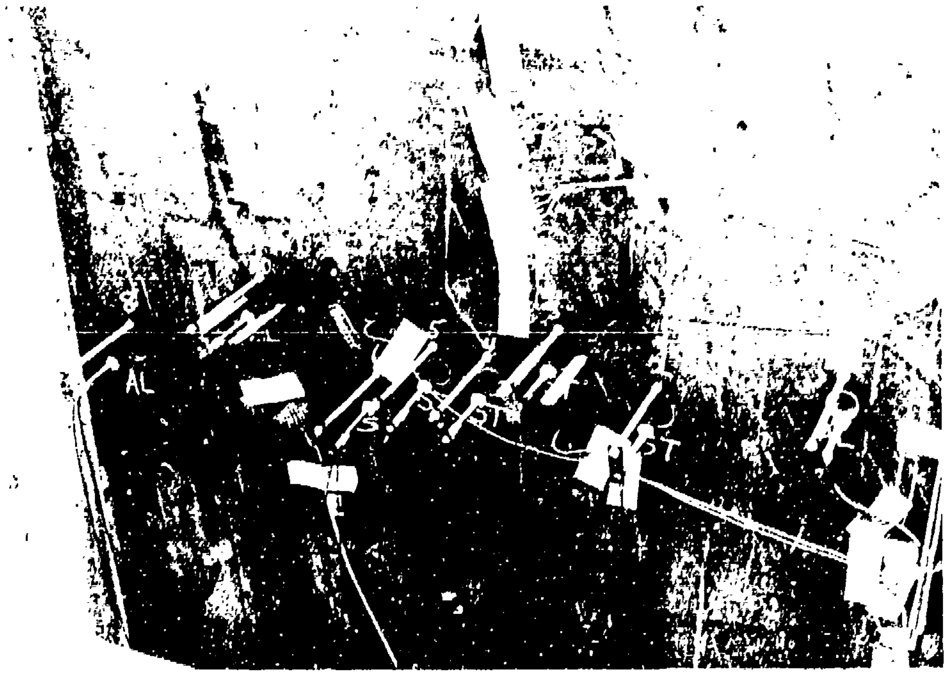


Figure 27. Position Transducer Setup for Test 6.

b. Test 7

This test was conducted with the 2.4-pound cased charge simulating the AN-Mk 1. This test also had two side-on pressure gages (P1, P2), however, for this test, the gages were placed on separate stands with one gage positioned 30 inches away from the charge and the second gage positioned 48 inches away from the charge. Fragment stripper pipes were again placed in front of the gages to try and protect them from fragment impacts. Since the reflected pressure gages were so badly damaged in the previous test and very little data were obtained, it was decided to omit the reflected pressure gages and use only the side-on pressure gages. Similarly, the use of the impulse plugs in the previous test yielded very little usable data and their use were also omitted from this test. The number of sets of velocity screens was increased to two rows of four sets of screens per row. For ease in handling, the fiberboard was bundled in groups of 12 sheets per bundle. The velocity screens and the fragment recovery fiberboard bundles were positioned as shown in Figure 28. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments slightly damaged the two side-on pressure gages, however, the damage did not affect the ability of the gages to measure the side-on pressures correctly. The eight sets of fragment velocity screens each recorded a maximum fragment velocity ranging between 2,976 fps and 6,575 fps. TABLE 10 provides the side-on pressure and impulse data. The first fiberboard bundle, which consisted of 12 sheets was ignited by a hot fragment buried in the middle of the bundle and burned completely, preventing the accurate recovery of the fragments in the bundle. Since the fragment data were incomplete, it was decided to repeat this particular test.

c. Test 8

Test 8 was a repeat test of the 2.4-pound cased charge test. This test also had two side-on pressure gages (P1, P2) however, they were positioned 48 inches away from the charge, one gage centered directly in line with the charge and the other gage offset at an angle. A fragment stripper pipe was again placed in front of each of the gages to protect them from fragment impacts. Since the purpose of this test was to obtain a good fragment count, impulse plugs, reflected pressure gages and fragment velocity screens were not used. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments damaged the two side-on pressure gages but the pressures were recorded. The fiberboard sheets survived this test and over 269 fragments were recovered. Coordinates for each fragment, as well as depth of penetration, size and weight, were recorded. The measured side-on pressures and impulses for this test are presented in TABLE 10. They compare favorably with the side-on pressures recorded for the previous test. Fragment data for this test are included in Appendix F.

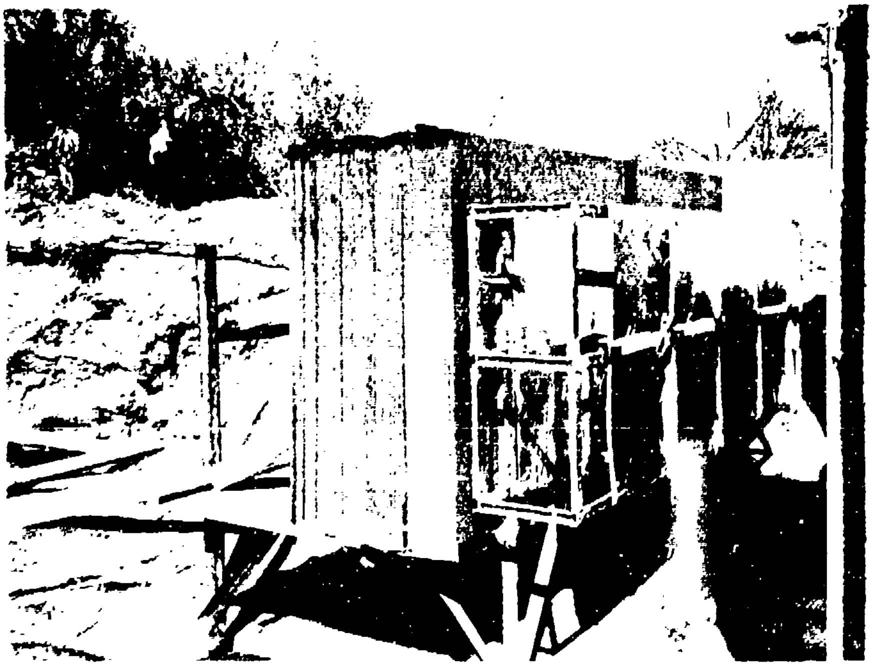


Figure 28. Velocity Screen and Fiberboard Setup for Test 7.

TABLE 10. DATA SUMMARY FOR CASED CHARGE TESTS 7 AND 8.

Gage Location	Measured Pressure (psi)		Integrated Impulse (psi-msec)	
	Test 7	Test 8	Test 7	Test 8
P1:	95.6	70	10.6	10.5
P2:	87	85	11.6	No Data

B. DETERMINATION OF EQUIVALENT BARE CHARGES

At the conclusion of the loads tests with both the cased and bare charges, an effort was undertaken to define an equivalent charge for both the scaled lightly cased charge (Mk 82) and the scaled heavily cased charge (AN-Mk 1). This equivalent charge was based on the determination of a bare explosive charge with an impulse distribution similar to that produced by both blast and fragments from a cased charge. This was done to allow panel tests to be conducted on the three panel types with both cased charges and equivalent impulse bare charges.

1. Cased Charge Blast Impulse

As is presented in the paragraphs above and in TABLES 8 and 10, the side-on airblast measured in the cased charge tests was reduced considerably from that produced by an equivalent amount of bare explosive. Standard tables from Reference 1 were used to determine an appropriate bare charge that would produce these blast impulses at the cited standoffs. TABLE 11 presents the charge weights determined for these impulses. This measured airblast was simply added to the fragment impulse described below to establish an equivalent charge.

TABLE 11. 2.7- AND 2.4-POUND CASED CHARGE MEASURED AIRBLAST IMPULSE AND CORRESPONDING BARE CHARGES.

Charge (Test)	Measured Impulse (psi-ms)	Equivalent Bare Charge Weight (pounds)
2.7 (6)	31.5	2.373
2.4 (7,8)	10.6	0.567

2. Cased Charge Fragment Impulse

As is described in the paragraphs above detailing the test procedures, fragments from Tests 6 and 8 were collected from the fiberboard panels and were weighed and measured. Impact location and depth of penetration were also documented. These measurements were used to calculate an impact velocity for each fragment using a relationship for steel fragments into Celotex fiberboard as a function of presented area, mass and depth of penetration as follows (from References 15 and 16):

$$V = 44740 \quad (eA)^{0.75} w^{-0.75}$$

where

- e = penetration depth, inches
- A = presented area, $inches^2$
- w = weight of fragment, grains
- V = velocity, feet/seconds

The tables in Appendices E and F include all data extracted from the fragment tests, and have columns of calculated impact velocity for each fragment. These calculated velocities, based on observed fragment penetration, mass and presented area are compared with measured maximum velocities observed in TABLE 12. The comparison presented in TABLE 12 is not conclusive. However, several qualifiers can be attached to the velocity data presented. First, the velocity screens break at the earliest arrival of very small particles. Thus, very small case fragments (those not captured by the fiberboard) could break the screens while they may not be imbedded and found for recording. Second, the smaller fragments are easy to overlook in the fiberboard. A small magnet is used to detect the fragments for recording which may miss some of the fragments weighing only a few grains. Finally, velocities close to those recorded were calculated, shown in Appendices E and F, but were not included in TABLE 11 because they were not assigned a corresponding screen number due to their estimated location. For the 2.7-pound Test 6 (light case), fragment velocities as high as 5971 fps, 9180 fps, and 5572 fps were calculated (Fragments 169, 170, and 171), but were noted as just missing the screen region (in two cases about 6 inches low, and in the third case about 2 inches high. For the 2.4-pound Test 8 (heavy case), velocities as high as 6462 fps were calculated (Fragment 108).

When a velocity for each fragment is known, momentum applied to the target can be calculated and a fragment impulse can be determined for each charge. Combining the calculated momentum with the catcher bundle size allows specific momentum or momentum per unit area (specific fragment impulse on the target) to be calculated.

TABLE 12. COMPARISON OF CALCULATED AND BREAK SCREEN VELOCITIES.

Screen No.	Test 6 2.7 Cased		Tests 7 and 8 2.4 Cased	
	Measured Velocity (fps)	Calculated Maximum Velocity (fps)	Measured Velocity (fps) (Test 7)	Calculated Maximum Velocity (fps) (Test 8)
Set 1:	6906	1411	6250	2082
Set 2:	6671	2920	4167	1646
Set 3:	6519	2150	4386	3290
Set 4:	6098	1588	2976	1910
Set 5:	N/A	N/A	6757	2688
Set 6:	N/A	N/A	4807	1950
Set 7:	N/A	N/A	5556	4177
Set 8:	N/A	N/A	6097	2259

Additional fragment data is presented in Figures 29-32. These figures show the fragment dispersion as a function of height along the length of the cylindrical charge. Figures 29 and 31 show the number of fragment impacts for the 2.7 and 2.4 (lightly and heavily cased) charges respectively. Figures 30 and 32 show the calculated impulse. The fragment impacts can be seen to be skewed towards the top of the fiberboard panels slightly in the figure for Test 6 and towards the bottom for Test 8. This is logical for Test 8 since the charges were detonated at the top, and the resulting Taylor angle will drive them off at an angle greater than perpendicular due to the interaction of the detonation front with the casing material. It is unclear why Test 6 indicates a concentration of fragments opposite what the Taylor angle would suggest.

The impulse distribution to be obtained and modeled after this fragment data is a function of the standoff of the weapon. Since the charges were located at a standoff of 9 feet from the 8 foot wide fiberboard panels, the total fragment impulse is assumed to be that lying in a circular arc of 48 degrees in the horizontal dimension, spanning vertically over the charge height plus and minus 10 degrees for the 2.7-pound charge and 11 degrees for the 2.4-pound charge based on the fragment concentrations in the data of Appendices E and F. From Figures 29-32 it can also be seen that for the 2.7-pound test, the impulse is evenly distributed over the 4 foot height, while for the 2.4-pound test 93 percent of the

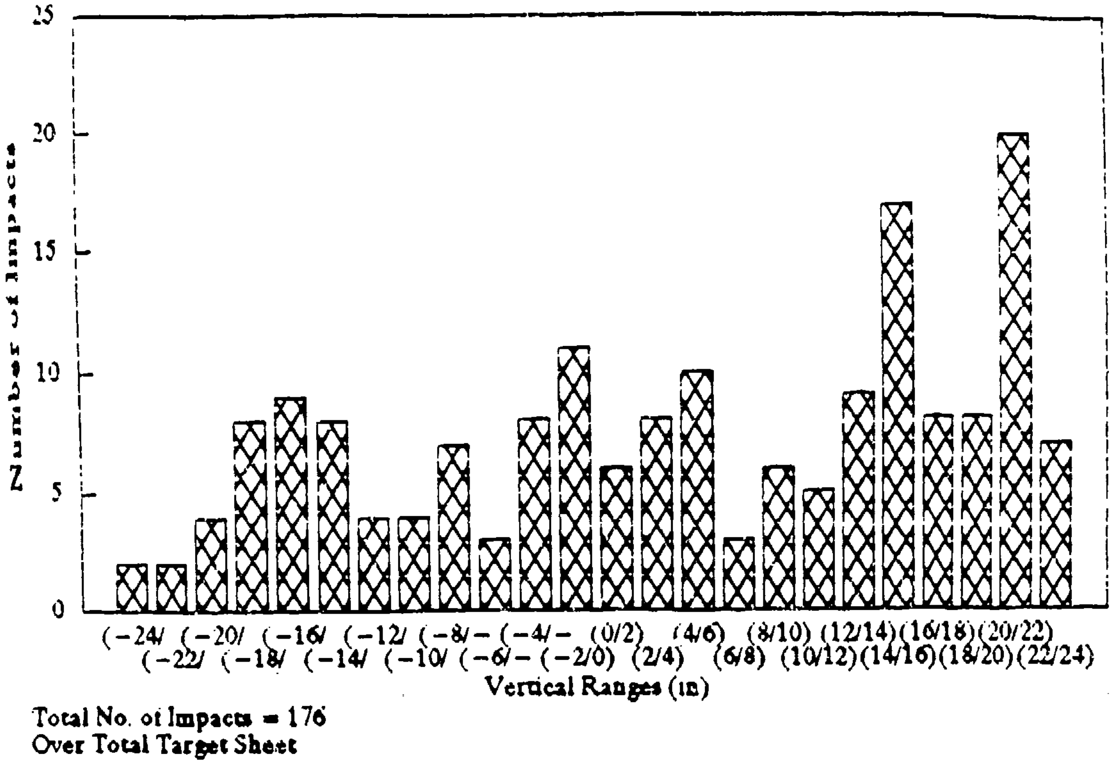


Figure 29. Number of Fragment Impacts for the 2.7-Pound (Lightly Cased) Test.

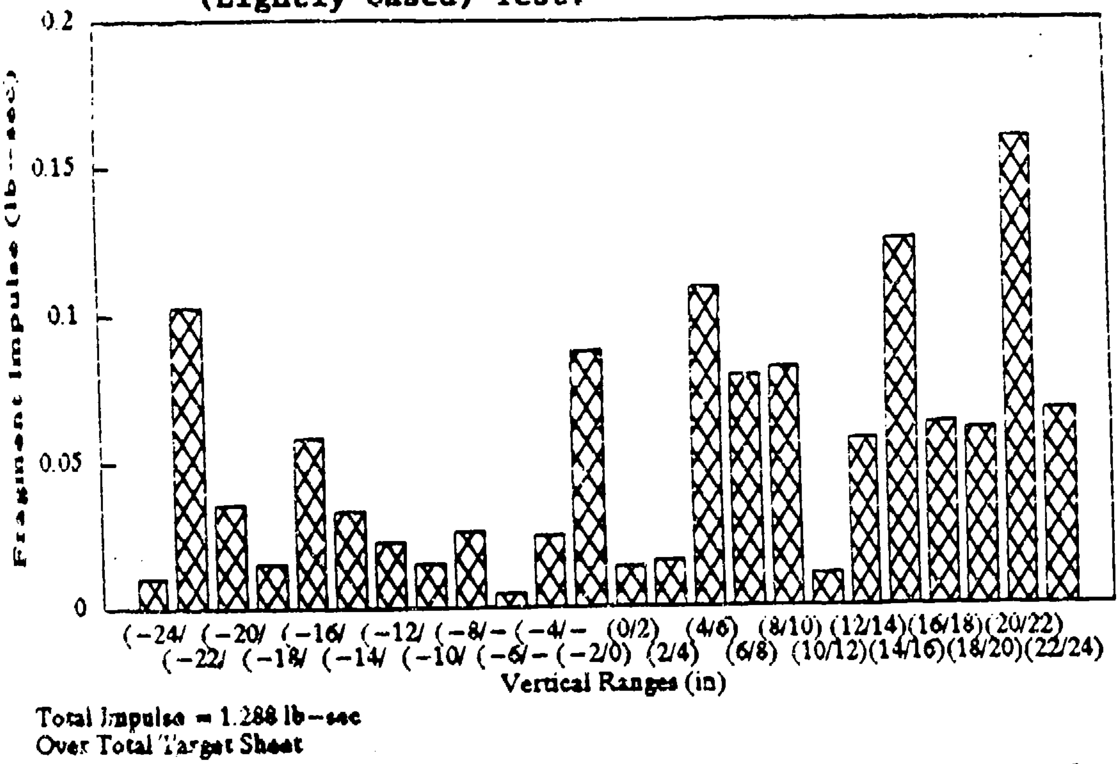


Figure 30. Fragment Impulse Distribution for the 2.7-Pound (Lightly Cased) Test.

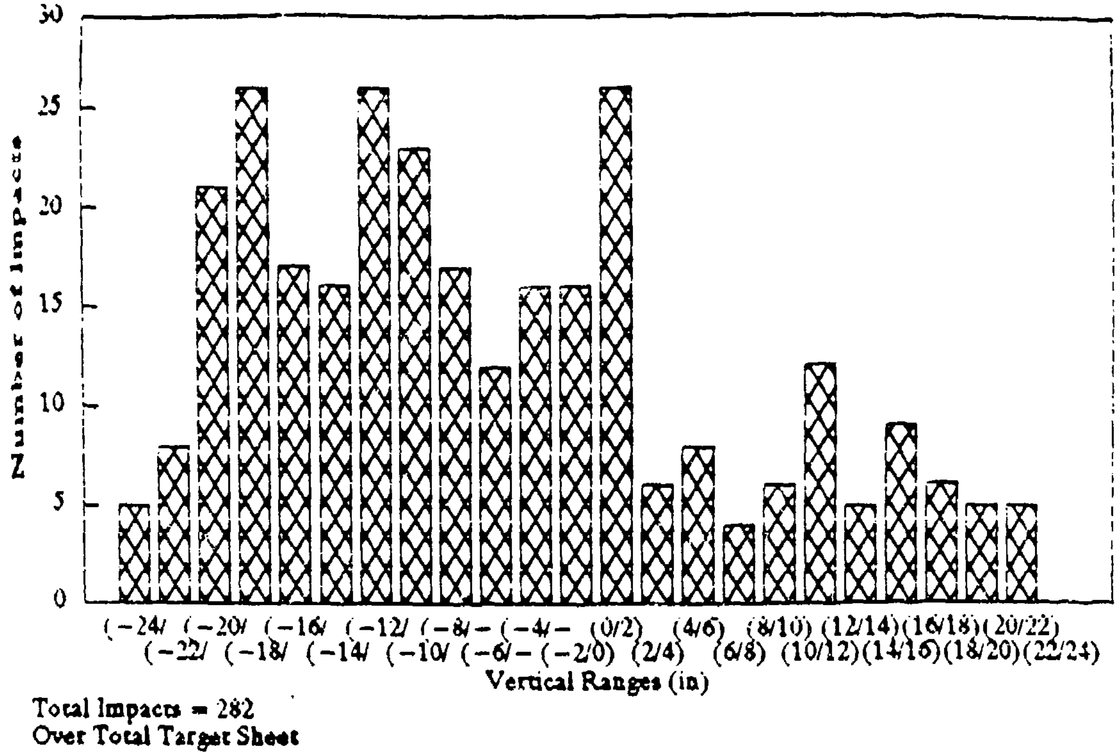


Figure 31. Number of Fragment Impacts for the 2.4-Pound (Heavily Cased) Test.

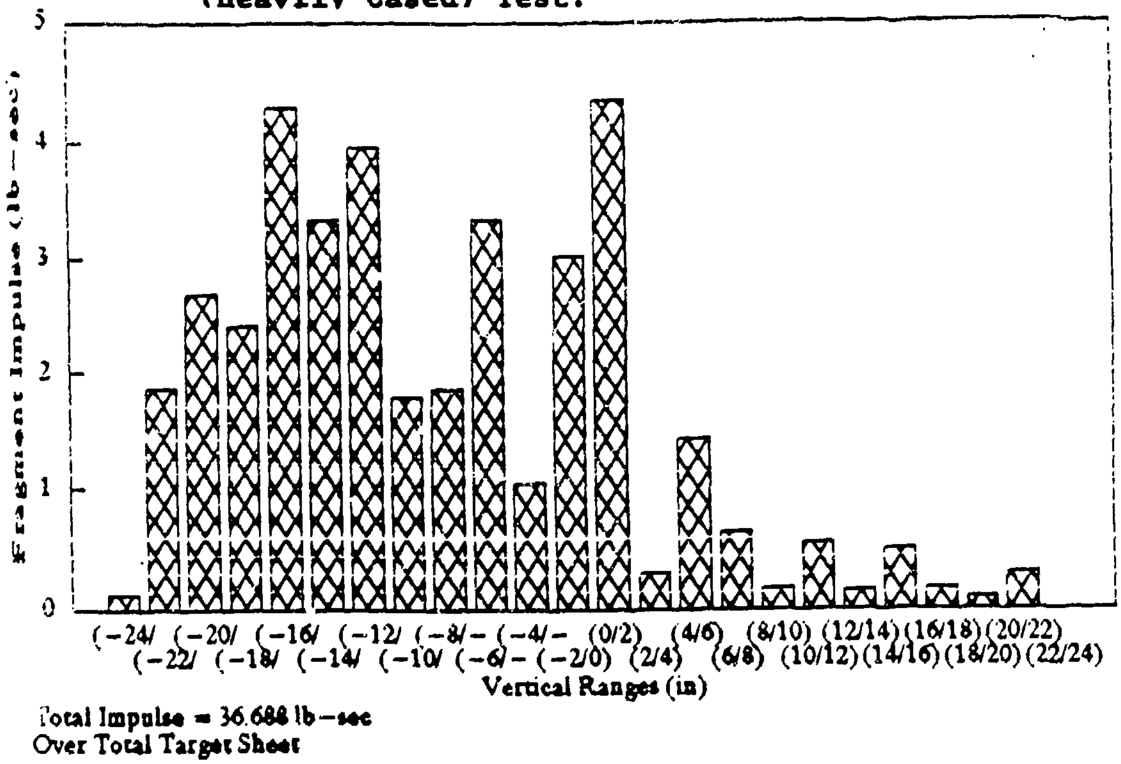


Figure 32. Fragment Impulse Distribution for the 2.4-Pound (Heavily Cased) Test.

for the 2.7-pound charge and 11 degrees for the 2.4-pound charge based on the fragment concentrations in the data of Appendices E and F. From Figures 29-32 it can also be seen that for the 2.7-pound test, the impulse is evenly distributed over the 4 foot height, while for the 2.4-pound test 93 percent of the impulse is distributed over 75 percent of the height. Using a relationship for the impulse at some radius from the surface center combined with the above data, specific impulses for the two charges can be defined for different standoffs.

$$i_r = i_0 R \left(\frac{\theta}{2}\right) / r$$

where

i_0 = impulse at the surface center, psi-ms
i_r = impulse at the radius, r, psi-ms
r = radius from surface center, inches
R = standoff from charge to surface, inches

From the data, the 2.7-pound charge had a total impulse of 1.288 pound-second and the 2.4-pound charge had a total impulse of 36.688 pound/second. TABLE 13 shows the fragment specific impulses calculated for three standoffs. Figure 33 shows the distributions for the 2.7-pound and 2.4-pound fragment impulses at a 12-inch standoff.

TABLE 13. CALCULATED IMPULSES FOR THE CASED CHARGES AT 6 INCH, 12 INCH AND 18 INCH STANDOFFS.

Charge Type	Impulse (psi-ms)		
	6 inch Standoff	12 inch Standoff	18 inch Standoff
2.7-pound Cased	20.0	8.62	5.04
2.4-pound Cased	919.7	373.14	208.54

3. Equivalent Charge Definition

To define the equivalent charges, the calculated impulse distributions for the bare charges equivalent to the measured side-on blast impulse from Tests 6 and 7 were superimposed on the fragment impulse distributions calculated and shown in Figure 33. Appendix G presents these calculations. Bare explosive charges which would produce impulse distributions very similar to the predicted blast and fragment impulses of the 2.7-pound and 2.4-pound cased charges were then determined. An equivalent charge of 2.373 pounds at

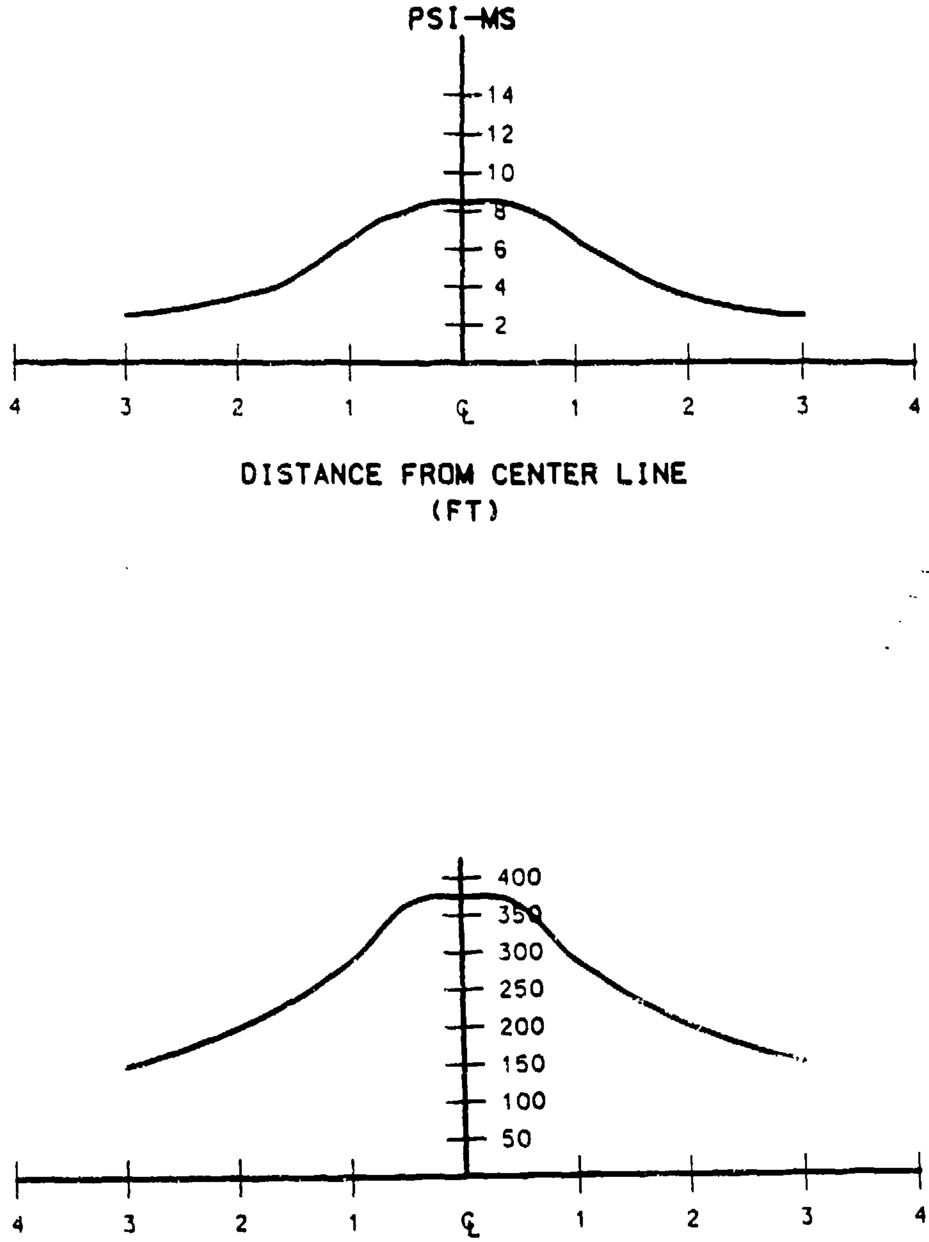


Figure 33. Impulse Distributions for the 2.7-Pound and 2.4-Pound Cased Charges at a 12 inch Standoff.

identical standoff was chosen to simulate the 2.7-pound cased charge. An equivalent charge of 2.8 pounds at slightly larger standoffs (7.2 inches, 15.6 inches, and 22.8 inches) was chosen to simulate the 2.4-pound cased charge. Figures 34 and 35 show plots of the calculated and predicted impulse distributions of the cased charges and equivalent bare charges respectively.

C. PANEL TESTS

As previously mentioned, cased charge tests and equivalent bare charge tests were conducted on three different types of panel constructions. The three construction types tested were the following: Type A - a standard reinforced concrete panel, Type B - a heavily reinforced concrete panel and Type C - a reinforced SIFCON panel. Four panels of each type were fabricated and one of the panels was tested against each of the following threats:

- 2.7-pound cased charge at 6 inch standoff
- 2.4-pound cased charge at 6 inch standoff
- 2.4-pound equivalent bare charge (2.4 pounds of C4 at 6 inch standoff) (replicates 2.7 cased)
- 2.8-pound equivalent bare charge (2.8 pounds of C4 at 7 inch standoff) (replicates 2.4 cased)

The following paragraphs describe the panel tests.

1. Type A Panel Tests

a. Test 9

Test 9 was conducted using the 2.7-pound cased charge. The test panel was mounted in the concrete reaction structure as shown in Figure 36 and the cased charge was positioned at the 6 inch standoff (Figure 37). This test utilized one high-speed camera positioned to record the reinforced concrete wall failure pattern. The back side of the wall was painted to aid in viewing the failure. The cased charge was detonated using an RP-83 detonator located approximately 1 inch from the top of the cased charge. The high-speed camera was used to provide the pulse that initiated the detonator. Post-test inspection of the wall showed that the cased charge had created a breach 20 inches wide by 14 inches high as shown in Figure 38. The wall also had a back face spall area of approximately 32 inches wide by 25 inches high. The wall had a major vertical failure about midway across the face, and had rotated approximately 5.75 inches at the center as shown in Figure 39. The charge side of the wall also exhibited major damage as shown in Figure 40. The wall damage was documented and the wall was removed. A schematic of the back face damage is shown in Figure 41. TABLE 14 presents a tabulation of debris velocity for Tests 9-20. TABLE 15 is a

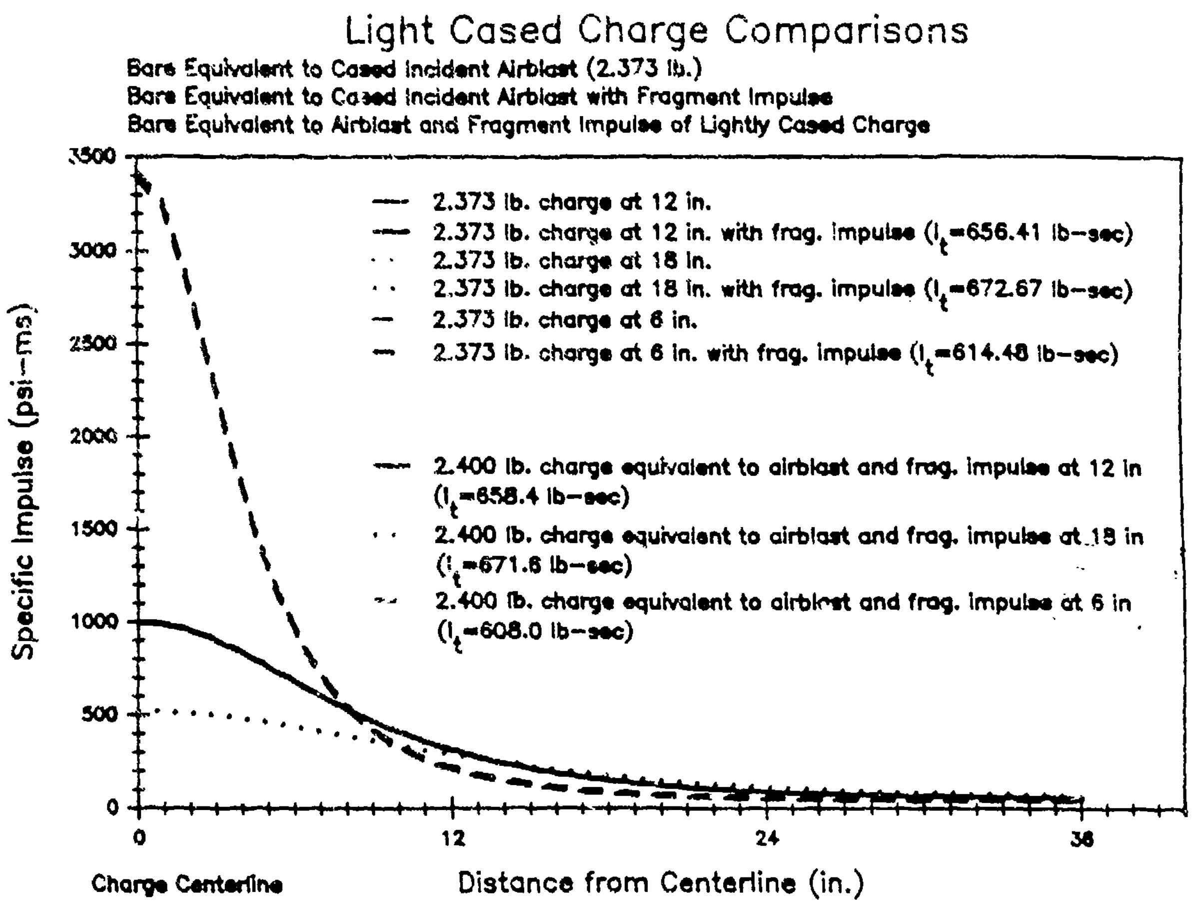


Figure 34. Comparison of the Predicted Blast and Fragment Impulse with the Equivalent Bare Explosive Charge for the 2.7-Pound Cased Charge.

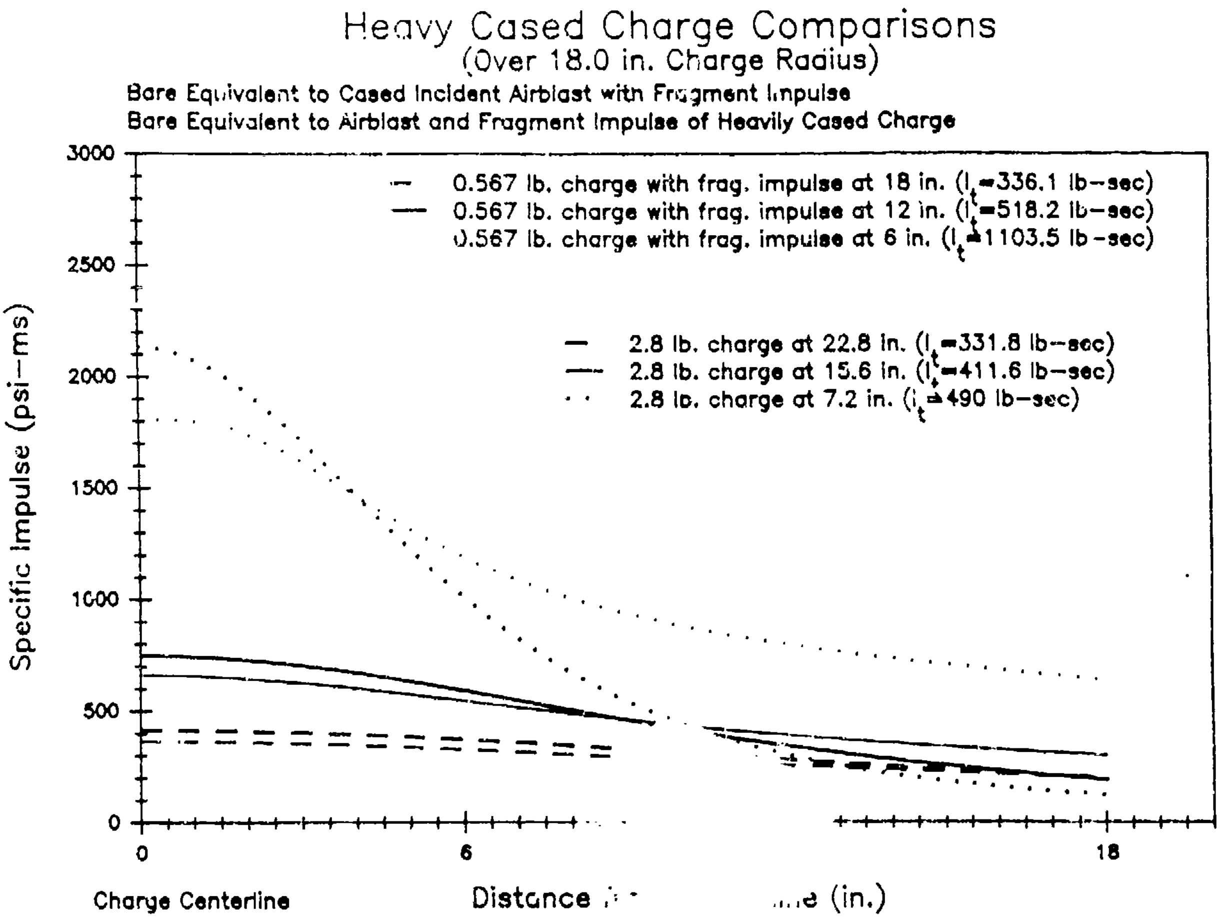


Figure 35. Comparison of the Predicted Blast and Fragment Impulse with the Equivalent Bare Explosive Charge for the 2.4-Pound Cased Charge.

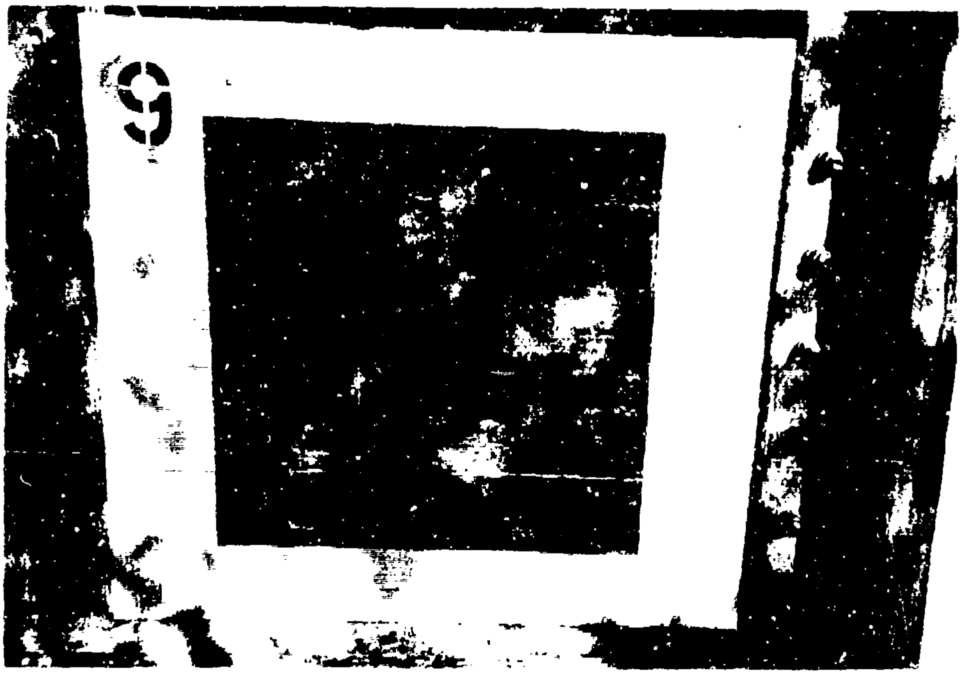


Figure 36. Panel-Type A Mounted in Reaction Structure Support Frame.

Figure 37. Charge Setup for Test 9.

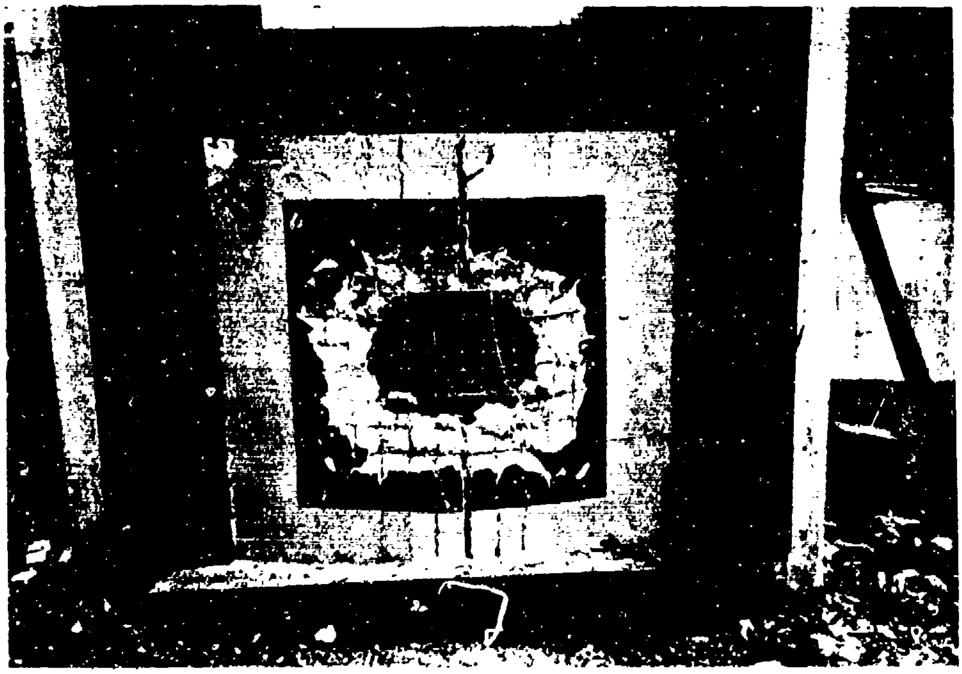


Figure 38. Test 9 Wall Damage (Type A, 2.7-Pound Cased Charge).

Figure 39. Test 9 Wall Rotation (Type A, 2.7-Pound Cased Charge).

Figure 40. Test 9 Charge Side Wall Damage (Type A, 2.7-Pound Cased Charge).

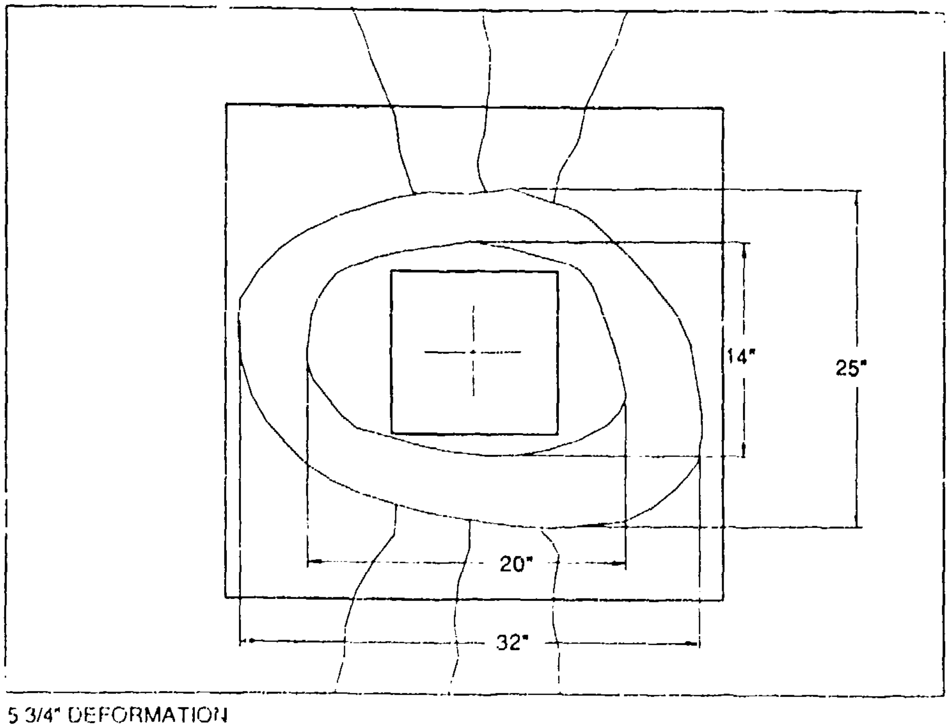


Figure 41. A Schematic of Test 9 Wall Damage (Type A, 2.7-Pound Cased Charge).

TABLE 14. PANEL DEBRIS VELOCITY.

Test	Charge Type	Wall Type	Max. Debris Velocity (fps)	Avg. Debris Velocity (fps)
9	2.7 Cased	A	N/A	N/A
10	2.7 Equivalent	A	168	70
11	2.4 Cased	A	336	76
12	2.4 Equivalent	A	140	70
13	2.7 Cased	B	210	60
14	2.7 Equivalent	B	140	52
15	2.4 Cased	B	291	76
16	2.4 Equivalent	B	120	31
17	2.7 Cased	C	---	---
18	2.7 Equivalent	C	---	---
19	2.4 Cased	C	288	70
20	2.4 Equivalent	C	105	---

TABLE 15. PANEL DAMAGE.

Test	Charge Type	Wall Type	Breach (Width x Height)	Spall (Width x Height)	Rotation (inches)
9	2.7 Cased	A	20 x 14	32 x 25	5.75
10	2.7 Equivalent	A	14 x 7	38 x 24	8.00
11	2.4 Cased	A	28 x 12	32 x 21	5.25
12	2.4 Equivalent	A	14 x 8	36 x 34	14.00
13	2.7 Cased	B	21 x 18	30 x 35	1.75
14	2.7 Equivalent	B	14 x 10[1]	22 x 37	2.00
15	2.4 Cased	B	28 x 24	35 x 41	1.75
16	2.4 Equivalent	B	---	---	2.25
17	2.7 Cased	C	---	Small Raised Section	0.75
18	2.7 Equivalent	C	---	Small Raised Section	2.00
19	2.4 Cased	C	12 x 8	24 x 13	.875
20	2.4 Equivalent	C	---	---	1.25

Note: (1) Not a complete breach through the thickness.

summary of wall damage for those tests. Review of the high-speed footage indicated that the backface failure was hemispherical in pattern over the 12 inch red square.

b. Test 10

Test 10 was conducted on the Type A panel using the equivalent bare charge (replicating the 2.7 cased) which was 2.4 pounds of C4 at a standoff of 6 inches. The wall was bolted to the reaction structure. A second high-speed camera and a grid background for use in measuring the wall fragment velocities were introduced for this test. The wall sustained a considerable amount of damage as shown in Figure 42. An area approximately 14 inches wide by 7 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 43. The reinforcement was deformed but did not fail. The small rubble was removed and a complete breach 14 inches by 7 inches was evident (Figure 44). The wall spalled over an area approximately 38 inches wide by 24 inches high. A major vertical failure was evident midway across the span and the wall rotated 8 inches as shown in Figure 45. Damage to the charge side of the wall is shown in Figure 46. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge (the area painted red in Figure 36) deformed initially in a conical pattern with the debris initially emanating from the center of the panel and was ejected with considerable velocity. Additional fragments were ejected from the wall, however, these pieces were found to be traveling at much slower speeds. The evaluation of the film showed that the fastest fragments were traveling approximately 168 fps while the slower fragments were traveling at an average velocity of approximately 70 fps. The wall damage was documented and photographed and the wall was removed. A schematic of the back face is shown in Figure 47.

c. Test 11

This test involved the 2.4-pound cased charge and Panel-Type A. The cased charge was positioned 6 inches from the wall and detonated remotely using the high-speed camera to initiate the detonator. A post-test inspection showed that the wall had sustained major damage with a breach approximately 28 inches wide by 12 inches high as shown in Figure 48. The spall area was 32 inches wide by 21 inches high and several reinforcement bars were severed by the blast and casing fragments (Figure 49). The wall suffered a major vertical crack at midspan and rotated approximately 5.25 inches as shown in Figure 50. Damage to the charge side of the wall indicated a very directional casing fragment spray (Figure 51). The evaluations of the high-speed film showed that the wall failed similar to the previous cased charge test with a hemispherical failure directly behind the charge. The wall fragments in this area were ejected at a velocity of 336 fps as measured by the

Figure 42. Test 10 Wall Damage (Type A, 2.4-Pound Equivalent Charge).

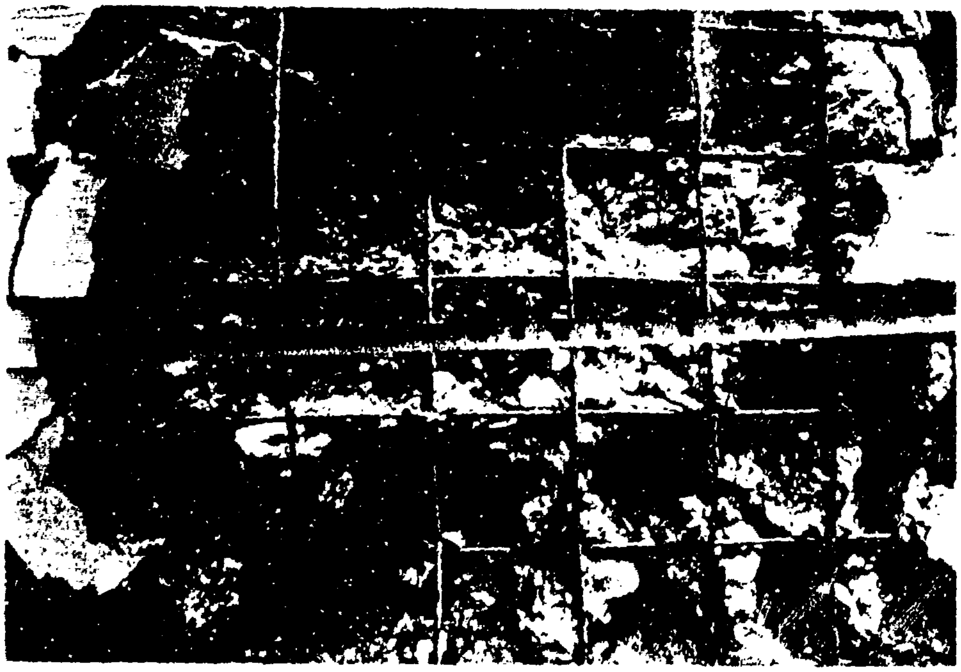


Figure 43. Test 10 Wall Damage Detail (Type A, 2.4-Pound Equivalent Charge).

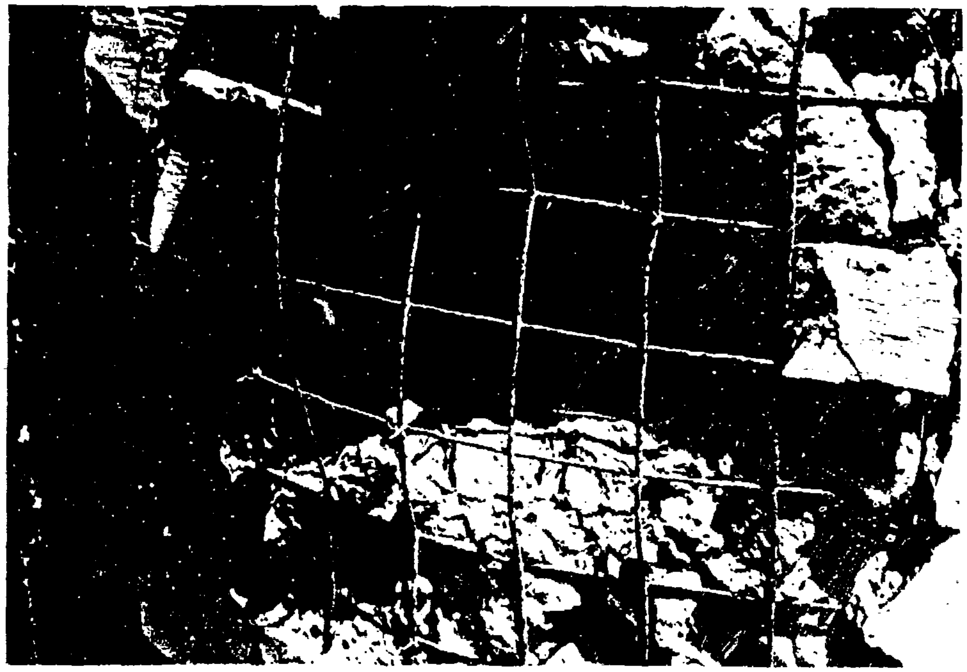


Figure 44. Test 10 Breach Detail after Debris Removal. (Type A, 2.4-Pound Equivalent Charge).

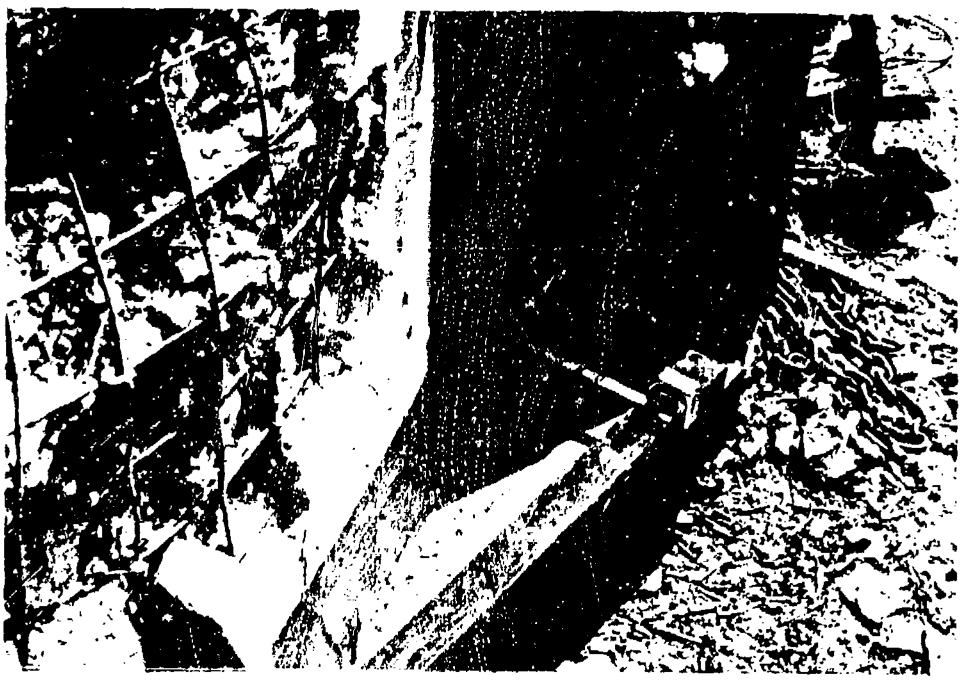


Figure 45. Test 10 Panel Rotation (Type A, 2.4-Pound Equivalent Charge).

Figure 46. Test 10 Charge Side Wall Damage (Type A, 2.4-Pound Equivalent Charge).

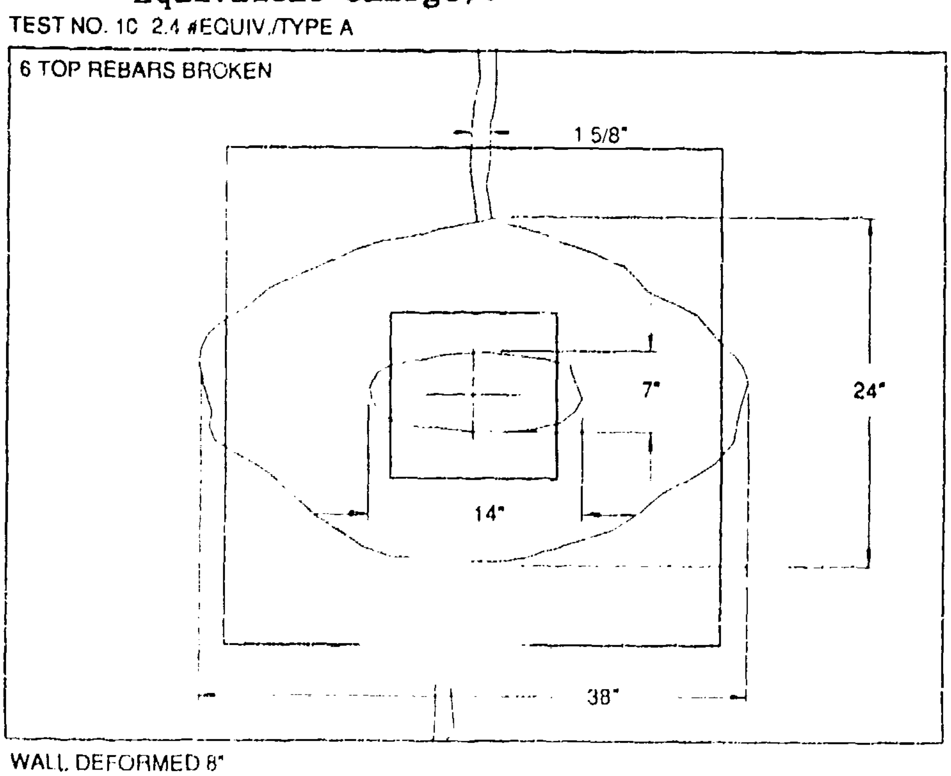


Figure 47. A Schematic of Test 10 Wall Damage (Type A, 2.4-Pound Equivalent Charge).

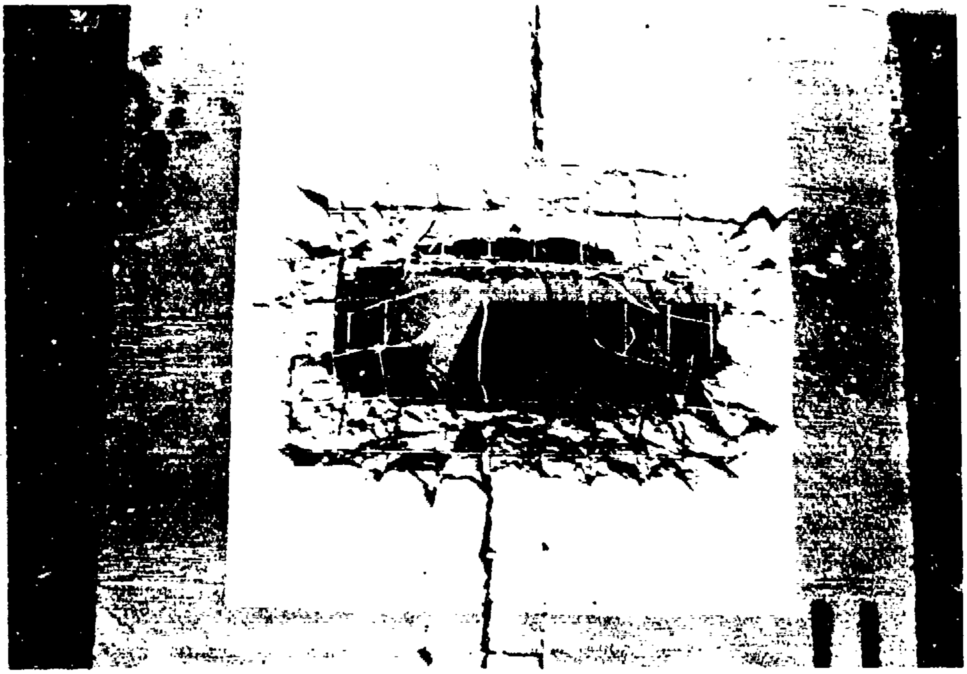


Figure 48. Test 11 Wall Damage (Type A, 2.4-Pound Cased Charge).

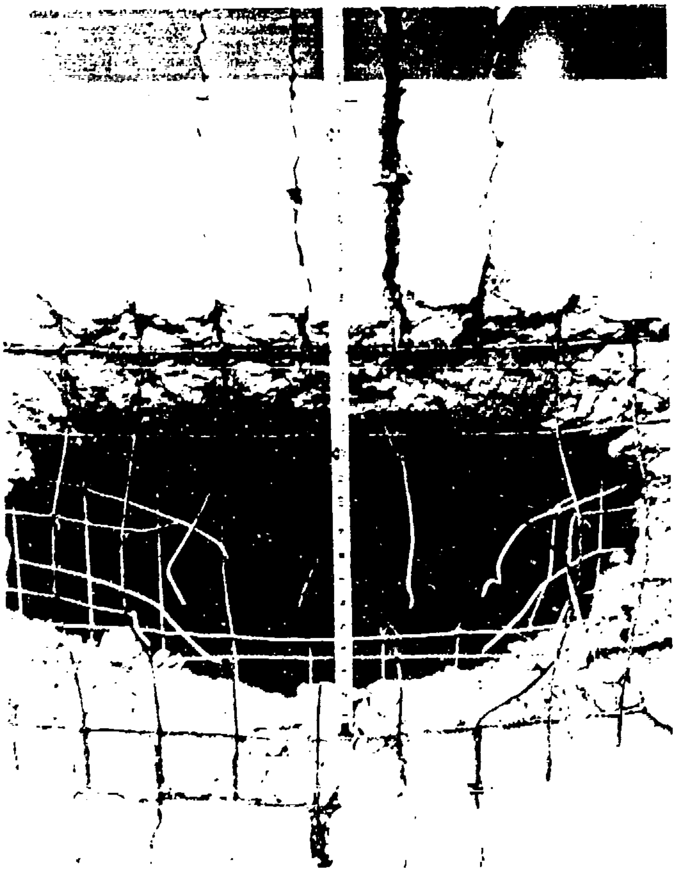


Figure 49. Test 11 Wall Damage Detail (Type A, 2.4-Pound Cased Charge).

Figure 50. Test 11 Wall Rotation (Type A, 2.4-Pound Cased Charge).

Figure 51. Test 11 Charge Side Wall Damage (Type A, 2.4-Pound Cased Charge).

high-speed camera. The slower fragments were traveling at approximately 76 fps. A schematic of the back face damage is shown in Figure 52.

d. Test 12

Test 12 was conducted on the Type A panel using the equivalent bare charge (replicating the 2.4 lb. cased charge) of 2.8 lbs. of C4 at a standoff of 7 inches The wall was bolted to the reaction structure and the bare charge positioned. The wall suffered a considerable amount of damage as shown in Figure 53. An area approximately 14 inches wide by 8 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 54. The reinforcement was deformed but did not fail. The wall sustained major damage over an area approximately 36 inches wide by 34 inches high consisting primarily of back face spall. A major vertical crack was found midway across the span and the wall rotated 14.0 inches as shown in Figure 55. Damage to the charge side of the wall is shown in Figure 56. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge deformed initially in a conical pattern with debris emanating from a point as was noticed on the previous equivalent bare charge test. The faster fragments were ejected with a velocity of 140 fps which is similar to the velocity of the fragments generated in Test 10. The slower fragments were traveling at a velocity of 70 fps as measured from the high-speed film which is also comparable to the velocities in Test 10. The damage was documented and photographed and the wall was removed. A schematic of the back face response is shown in Figure 57.

2. Type B Panel Tests

a. Test 13

Test 13 was conducted using the 2.7-pound cased charge against the heavier reinforced panel design. This particular test panel design was instrumented with Dynasen piezoresistive shock pressure carbon gages and with piezocrystals for measuring the time-of-arrival of the shock wave. Detailed descriptions of the instrumentation is presented in Section II of this report. The test panel was mounted in the concrete reaction structure and the cased charge was positioned at the 6 inches standoff. This test utilized one high-speed camera positioned to record the reinforced concrete wall failure pattern and a second high-speed camera to measure the resultant wall fragment velocities. The piezocrystals and piezoresistive shock pressure carbon gage outputs were recorded on magnetic tape for later analyses. The cased charge was detonated using an RP-83 detonator located approximately 1 inch from the top of the cased charge. Post-test inspection of the wall showed that the cased charge created an extensive amount of damage. The concrete was broken up into small pieces in an area 21 inches wide by 18

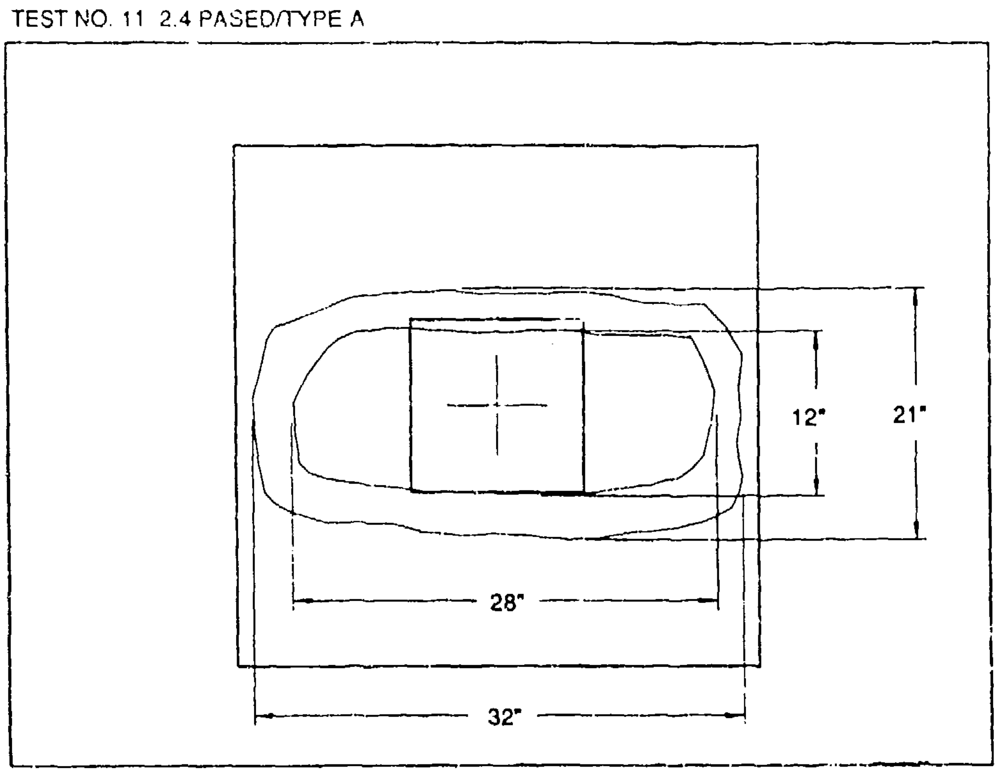


Figure 52. A Schematic of Test 11 Wall Damage (Type A, 2.4-Pound Cased Charge).

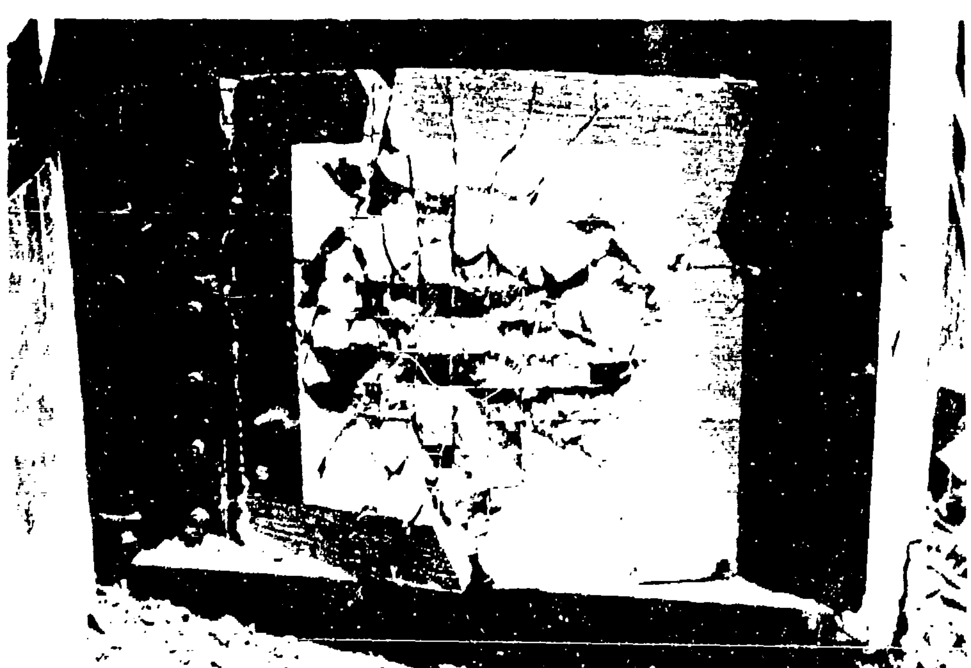


Figure 53. Test 12 Wall Damage (Type A, 2.8-Pound Equivalent Charge).

Figure 54. Test 12 Wall Damage Detail (Type A, 2.8-Pound Equivalent Charge).

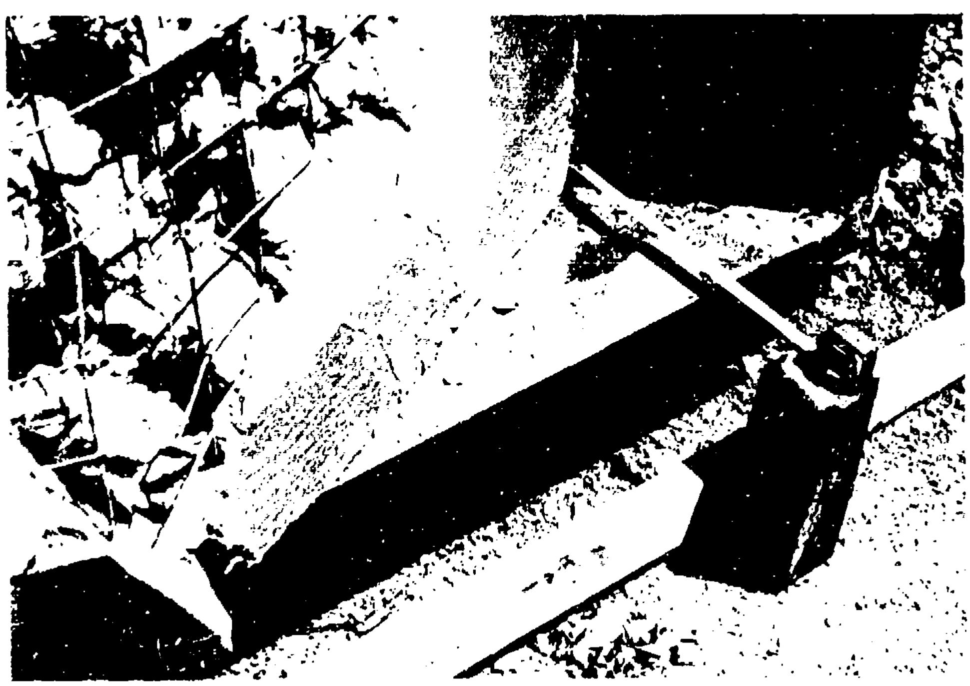


Figure 55. Test 12 Wall Rotation (Type A, 2.8-Pound Equivalent Charge).

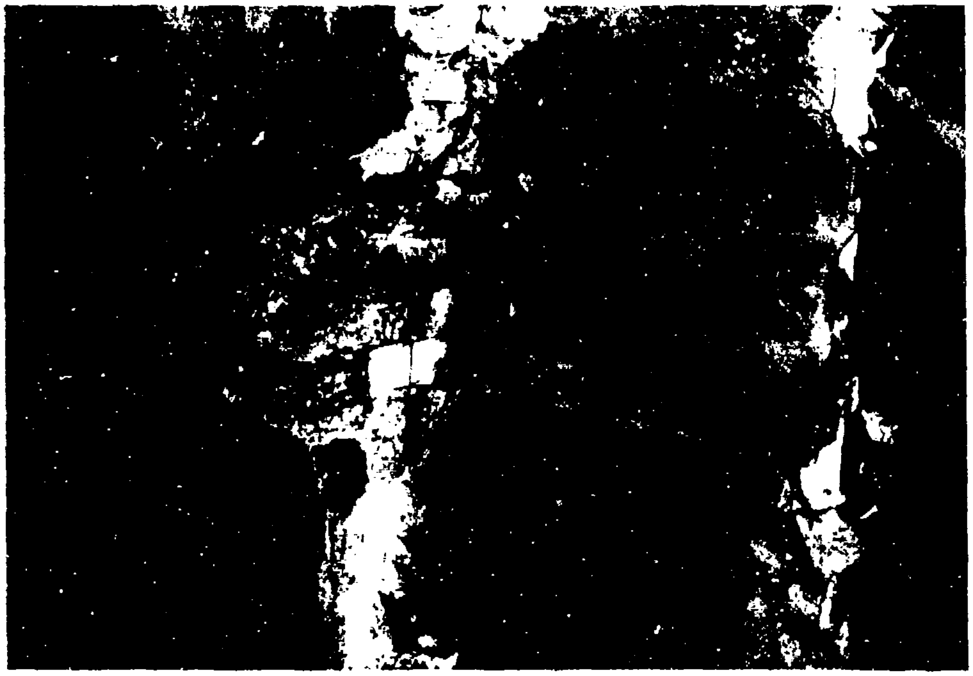


Figure 56. Test 12 Charge Side Wall Damage (Type A, 2.8-Pound Equivalent Charge).

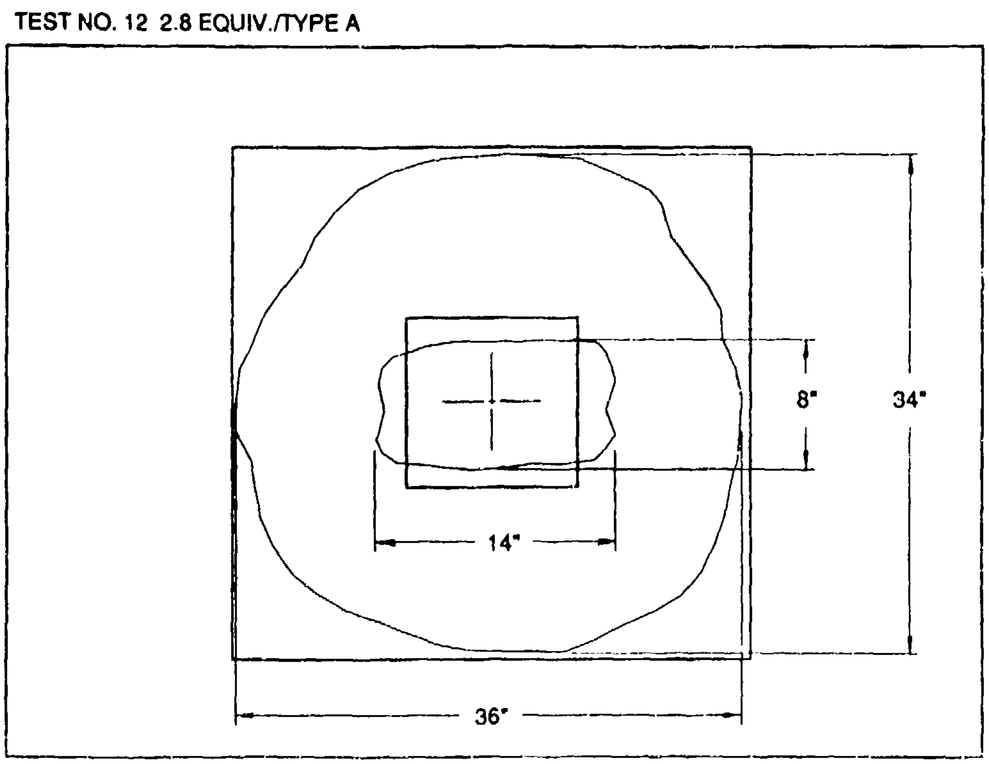


Figure 57. A Schematic of Test 12 Wall Damage (Type A, 2.8-Pound Equivalent Charge).

inches high as shown in Figure 58. The reinforcement was deformed but did not fail and the bulk of the concrete rubble was trapped by the reinforcement. The wall had a large spall area of about 30 inches wide by 35 inches high. The small rubble was removed from the wall revealing a breach 21 inches wide by 18 in high. The wall had a major vertical crack about 18 inches from the right side of the wall coinciding with the locations of the carbon gages. The midpoint of the wall rotated approximately 1.75 inches as shown in Figure 59. The charge side of the wall also exhibited major damage as shown in Figure 60. The high-speed films were reviewed and showed that the wall failed in a manner similar to the previous cased charge tests on the standard reinforced concrete panels, that is, hemispherical section of material behind the charge exiting at a high velocity. The wall fragments in this area were traveling at a speed of 210 fps as measured by the fragment high-speed camera. The slower fragments ejected later were traveling at approximately 60 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. The wall damage was documented and the wall was removed. A schematic of wall response is shown in Figure 61. TABLE 16 presents the peak pressures generated from carbon gage records for Tests 13 - 16 and 19 - 20. TABLE 17 presents TOA data.

b. Test 14

Test 14 was conducted using our equivalent bare charge (replicating the 2.7-pound cased charge) weighing 2.4 pounds at a standoff of 6 inches The instrumented wall was bolted to the reaction structure. The piezocrystals and the piezoresistive carbon gage outputs were recorded on magnetic tape. The wall sustained a considerable amount of damage as shown in Figure 62. The wall had a vertical crack coinciding with the positioning of the carbon gages. An area approximately 14 inches wide by 10 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 63. The reinforcement in this test was also deformed but did not fail and served to trap the smaller rubble. Unlike the previous test, the entire thickness of the wall was not broken up and a complete breach was not found. The portion of the wall that sustained spall damage was approximately 22 inches wide by 37 inches high. The wall rotated 2.0 inches at the mid-point as shown in Figure 64. Damage to the charge side of the wall is shown in Figure 65. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge deformed initially in a conical pattern with debris originating at a point and was ejected with considerable velocity. The fastest fragments were traveling approximately 140 fps while the slower fragments were traveling at an average of approximately 52 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. The wall damage was documented and photographed and the wall was removed. A schematic of the wall failure is presented in Figure 66.

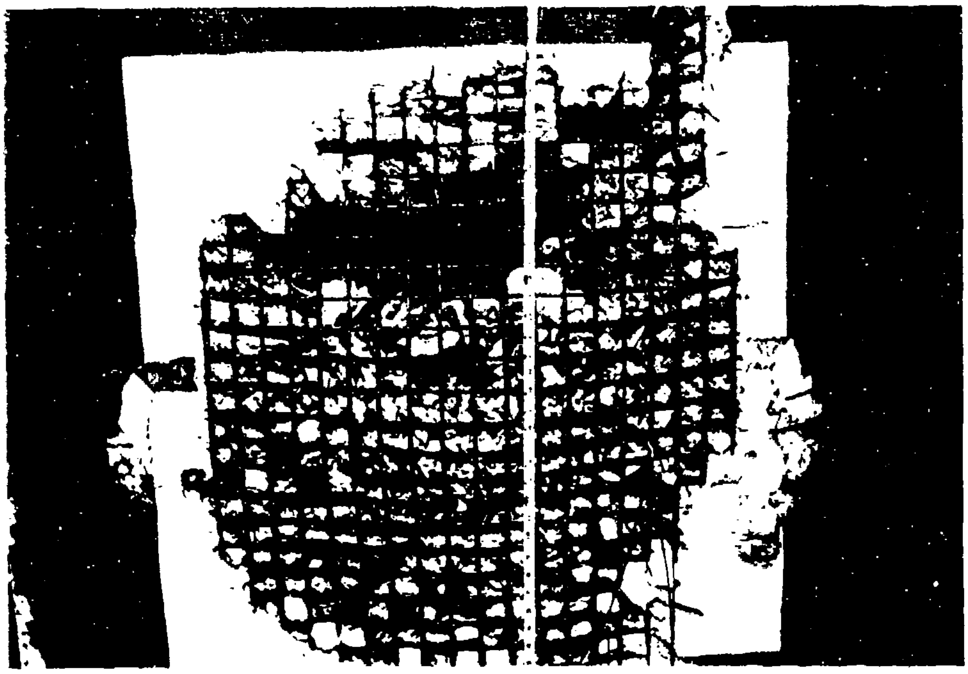
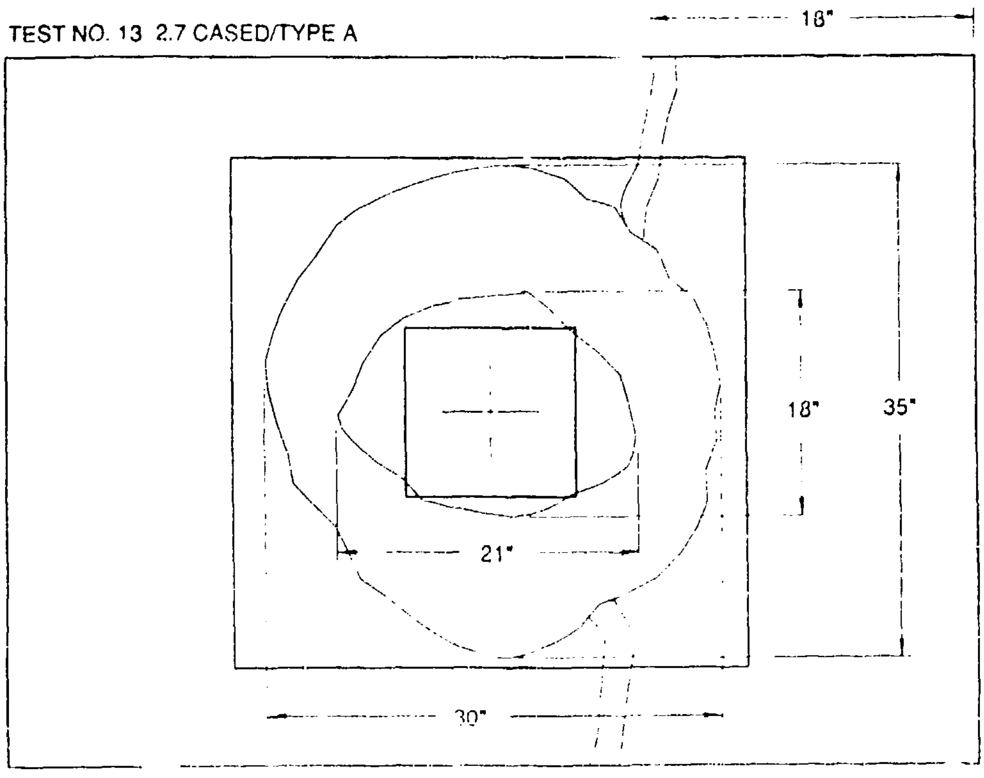


Figure 58. Test 13 Wall Damage (Type B, 2.7-Pound Cased Charge).

Figure 59. Test 13 Wall Rotation (Type B, 2.7-Pound Cased Charge).

Figure 60. Test 13 Charge Side Wall Damage (Type B, 2.7-Pound Cased Charge).

TEST NO. 13 2.7 CASED/TYPE A



1 3/4" DEFO TION

Figure 6. A Schematic of Test 13 Wall Damage (Type B, 2.7-Pound Cased Charge).

TABLE 16. PIEZORESISTIVE SHOCK PRESSURE CARBON GAGE (CG) DATA.

Gage Location (App. C Location)	Pressures (psi)					
	Test 13 (B/2.7C)	Test 14 (B/2.4E)	Test 15 (B2.4C) (2nd Peak)	Test 16 (B/2.8E)	Test 19 (C/2.4C) (2nd Peak)	Test 20 (C/2.8E)
CG1: (11)	34467	7250	58000	14000	>100000	>100000
CG2: (9)	33495	4133	43500	8200	68000 (22000)	14500
CG3: (12)	32973	4688	39000 (6000)	4592	18000	9650
CG4: (10)	35054	3432	15000 (7500)	No Data	7000 (3000)	3000

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge
(B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge
(B/2.4C) = Wall Type B/2.4-pound Cased Charge
(B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge
(C/2.4C) = Wall Type C/2.4-pound Cased Charge
(C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

TABLE 17. PIEZOCRYSTAL SHOCK WAVE ARRIVAL TIMES.

Crystal Location	Time of Arrival (μsec)					
	Test 13 (B/2.7C)	Test 14 (B/2.4E)	Test 15 (B2.4C)	Test 16 (B/2.8E)	Test 19 (C/2.4C)	Test 20 (C/2.8E)
T1:	71.8	65	104	47	105	60
T2:	76.8	66	111	51	120	67
T3:	77.3	67	116	53	120	74
T4:	77.4	68	122	---	120	80
T5:	77.7	60	122	52	125	86
T6:	77.7	---	122	51	125	91
T7:	77.7	---	122	51	125	91
T8:	77.7	60	122	53	125	93

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge
(B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge
(B/2.4C) = Wall Type B/2.4-pound Cased Charge
(B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge
(C/2.4C) = Wall Type C/2.4-pound Cased Charge
(C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

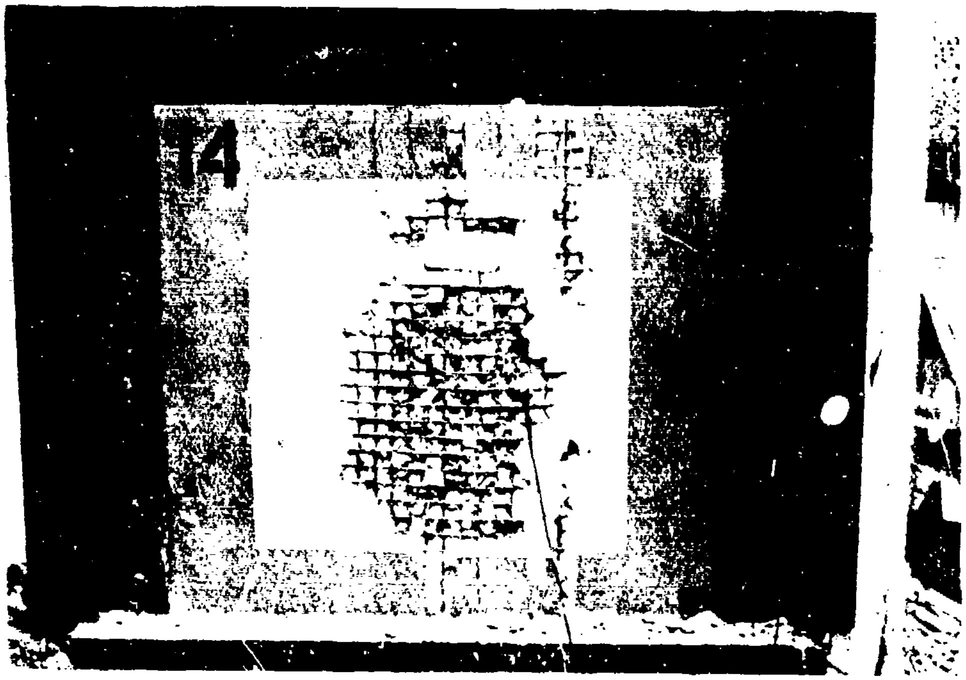


Figure 62. Test 14 Wall Damage (Type B, 2.4-Pound Equivalent Charge).

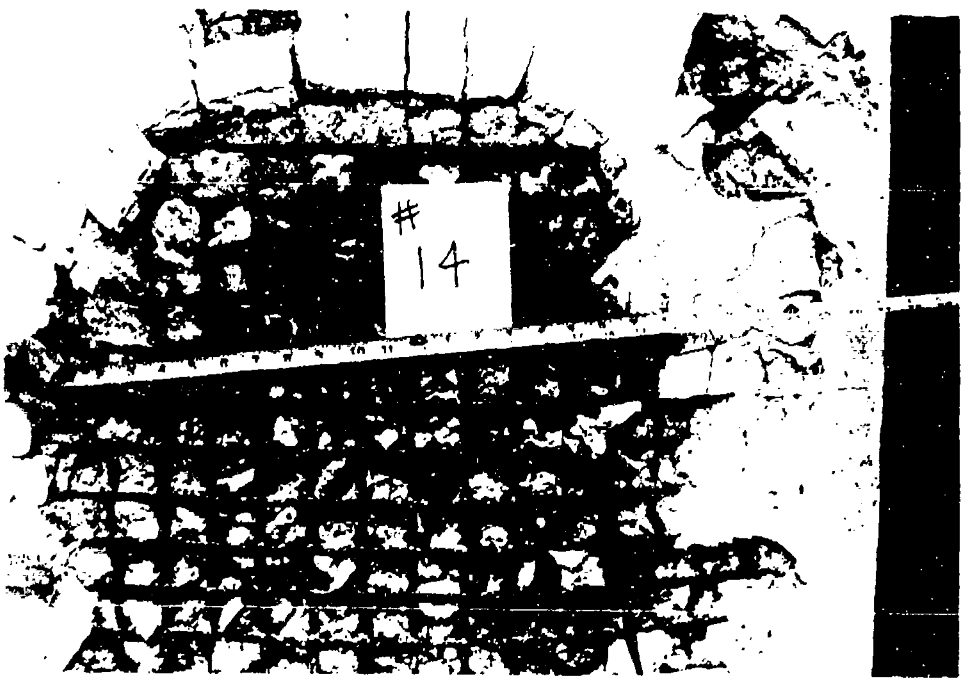


Figure 63. Test 14 Wall Damage Detail (Type B, 2.4-Pound Equivalent Charge).

Figure 64. Test 14 Wall Rotation (Type B, 2.4-Pound Equivalent Charge).

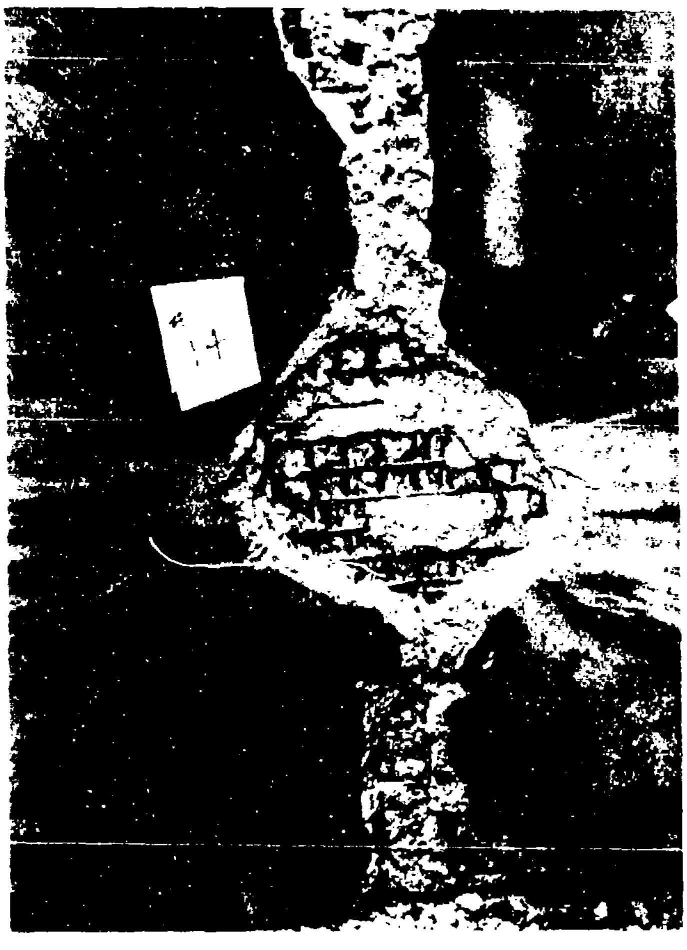


Figure 65. Test 14 Charge Side Wall Damage (Type B, 2.4-Pound Equivalent Charge).

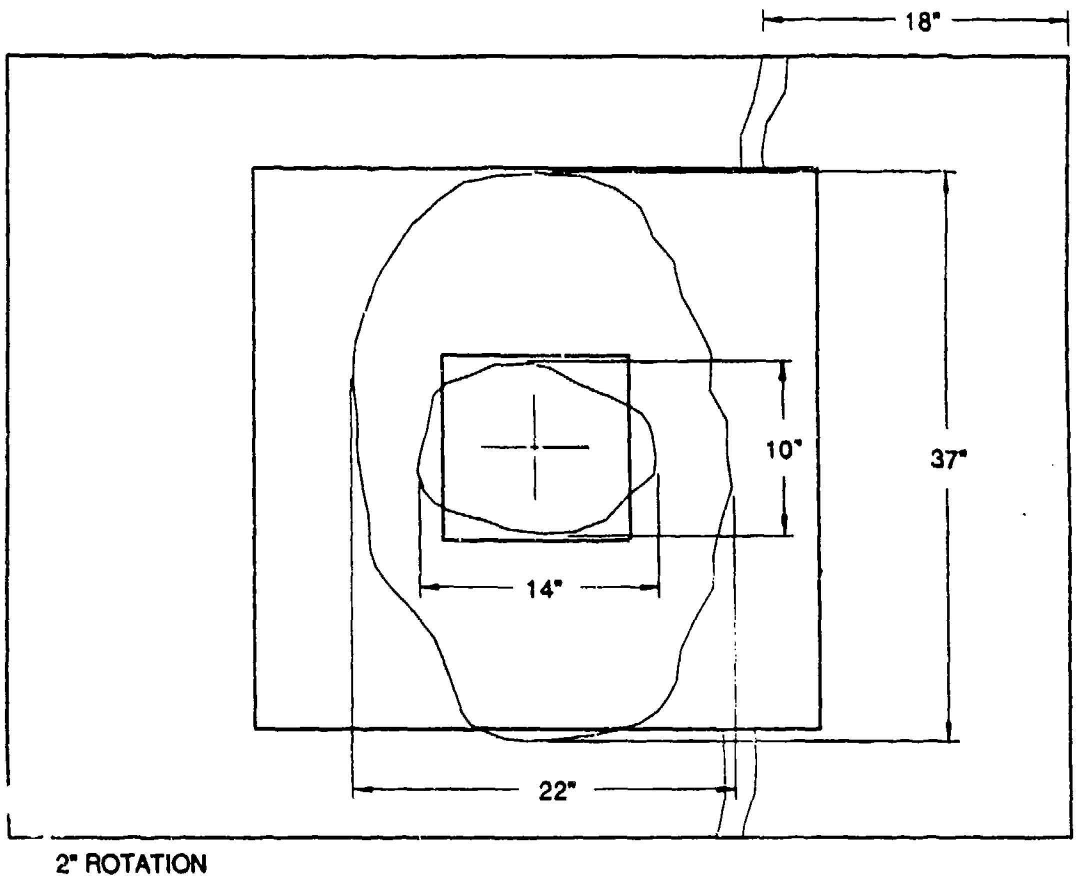


Figure 66. A Schematic of Test 14 Wall Damage (Type B, 2.4-Pound Equivalent Charge).

c. Test 15

This test involved the 2.4-pound cased charge. The cased charge was positioned 6 inches from the heavier reinforced wall and detonated remotely using the high-speed camera to initiate the detonator. The outputs of the piezoresistive shock pressure carbon gages and the piezocrystals were recorded on magnetic tape for later processing. A post-test inspection of the wall showed that the wall had sustained major damage with a breach approximately 28 inches wide by 24 inches high as shown in Figure 67. The spall area was 35 inches wide by 41 inches high. The reinforcement steel was deformed by the blast and casing fragments (Figure 68). The wall sustained several vertical cracks and rotated approximately 1.75 inches as shown In Figure 69. Damage to the charge side of the wall (Figure 70) indicated a very directional casing fragment spray. The evaluations of the high-speed film showed that the wall failed similar to the previous cased charge test with a hemispherical failure directly behind the charge. The wall fragments in this area were ejected at a velocity of 291 fps as measured by the fragment high-speed camera. The slower fragments were traveling at approximately 76 fps. Computer generated plots of the outputs from the crystals and from the carbon gages are presented in Appendix C. A schematic of the wall damage is shown in Figure 71.

d. Test 16

Test 16 was conducted on the Type B panel using the equivalent bare charge of 2.8 pounds of C4 (replicating the 2.4-pound cased charge) at a standoff of 7 inches The charge shape was changed for this test and a spherical charge was used instead of a cylindrical charge as had been used in all of the previous tests. The charge shape was changed to see what effect shape had on the damage mechanism and measured stress. The wall was bolted to the reaction structure and the bare charge positioned. The charge was remotely detonated using the RP-83 detonator which was initiated by a pulse from the high-speed camera used to record the wall failure mechanism. The damage suffered by the wall was considerably less than previous tests as shown in Figure 72. The wall suffered some small amounts of back face spall with no significant failures or breaches. A rotation of 2.25 inches was measured. Damage to the charge side of the wall is shown in Figure 73. The high-speed film from the fragment camera showed that very few fragments were ejected and the faster fragments were ejected with a velocity of 120 fps. The slower fragments were traveling at a velocity of 31 fps. The wall damage for this test and for Test 14 were very different in magnitude. The piezocrystals and the piezoresistive carbon gage outputs which had been recorded on magnetic tape were analyzed and plots of these data are presented in Appendix C. A schematic of wall damage is shown in Figure 74.

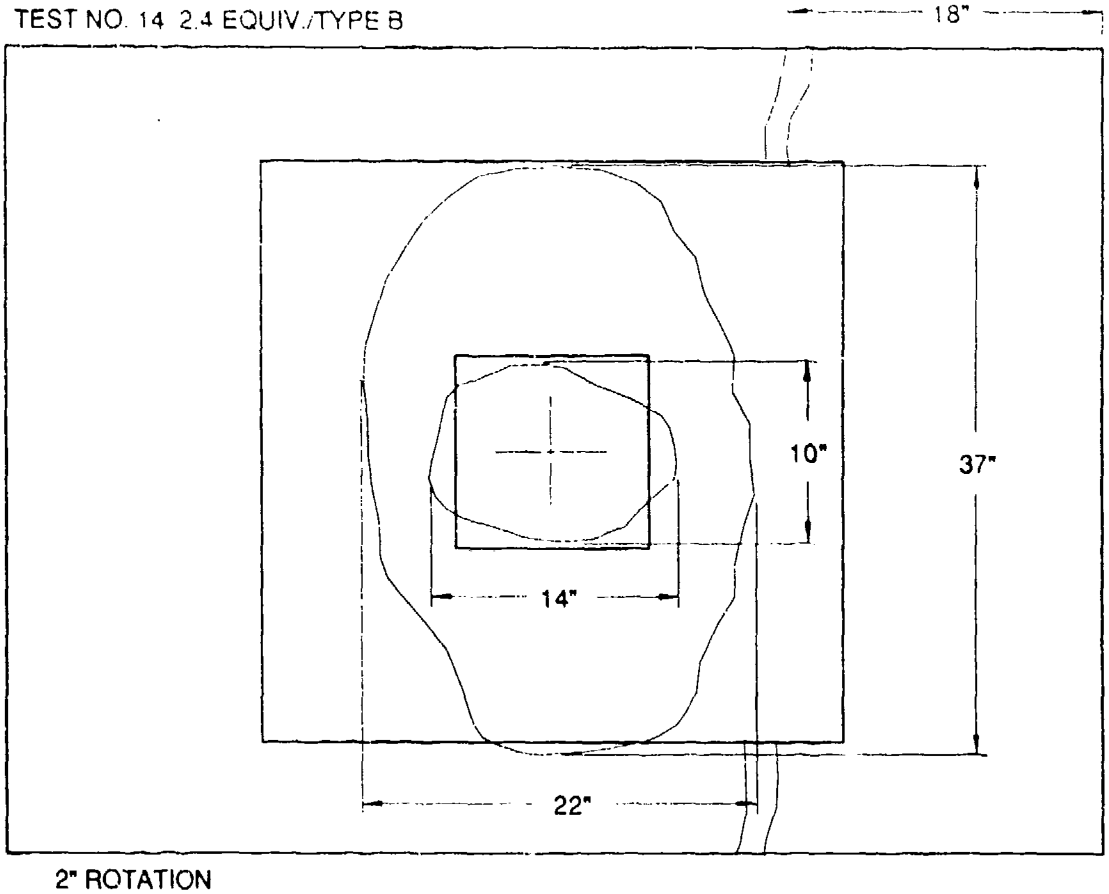


Figure 67. Test 15 Wall Damage (Type B, 2.4-Pound Cased Charge).

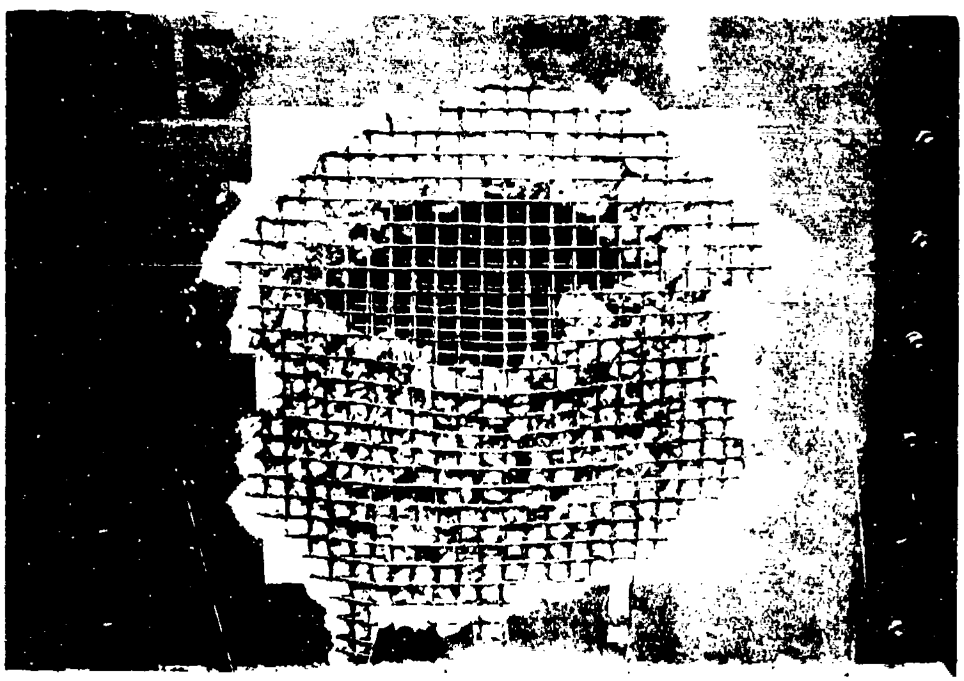


Figure 68. Test 15 Wall Damage Detail (Type B, 2.4-Pound Cased Charge.)

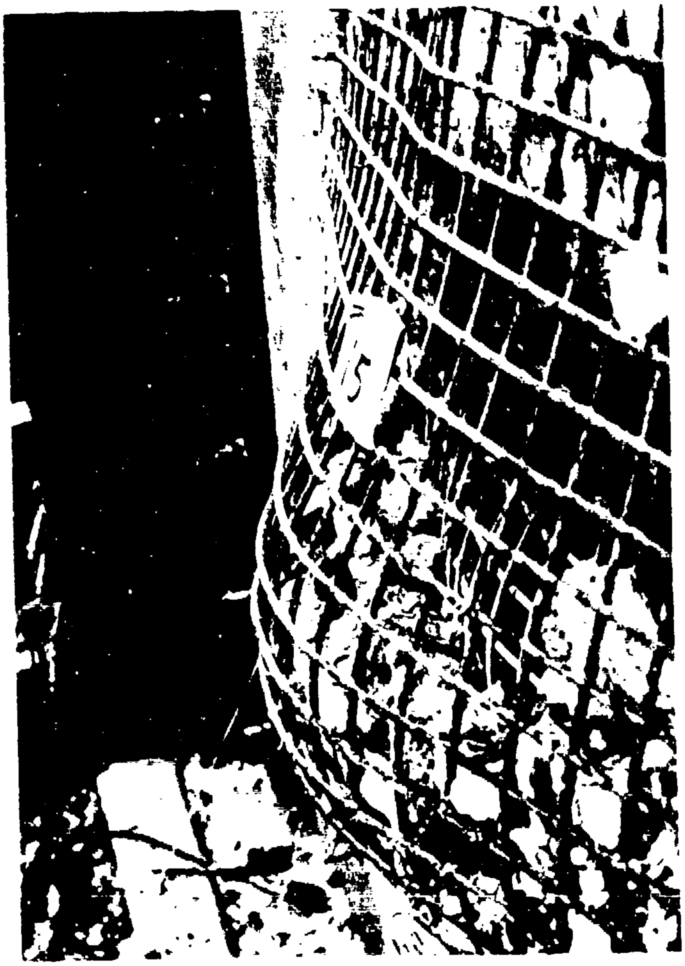


Figure 69. Test 15 Wall Rotation (Type B, 2.4-Pound Cased Charge).

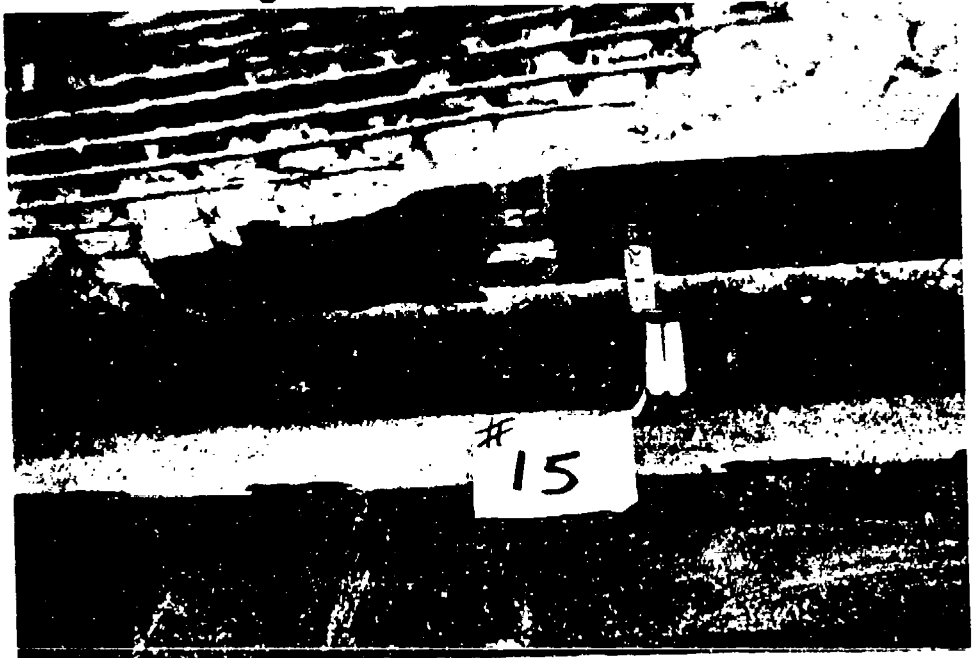


Figure 70. Test 15 Charge Side Wall Damage (Type B, 2.4-Pound Cased Charge).

Figure 71. A Schematic of Test 15 Wall Damage (Type B, 2.4-Pound Cased Charge).

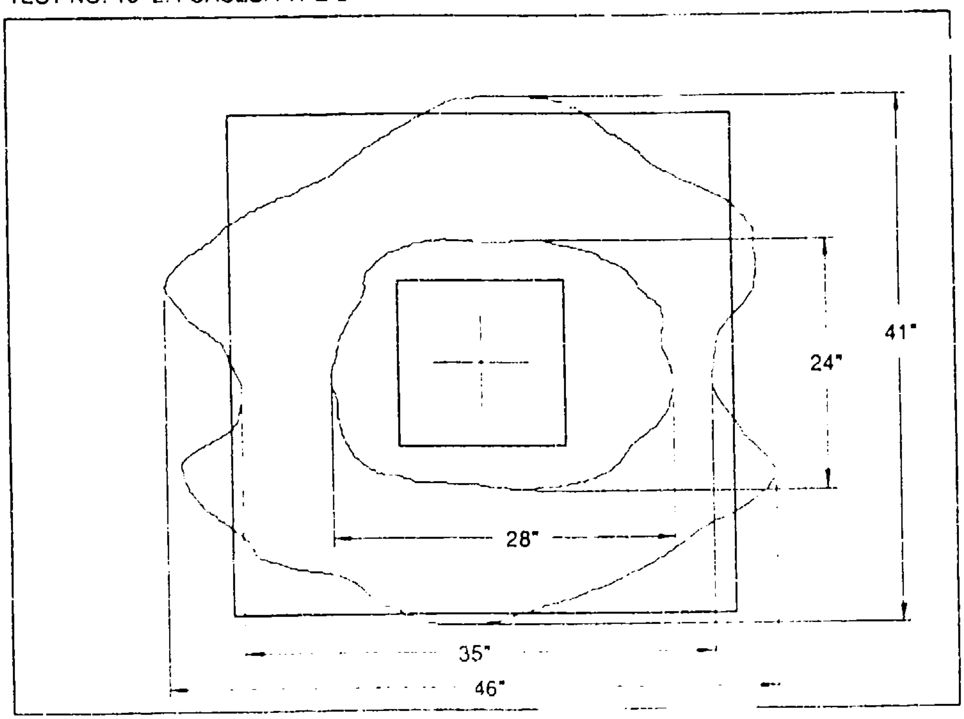


Figure 72. Test 16 Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge.)

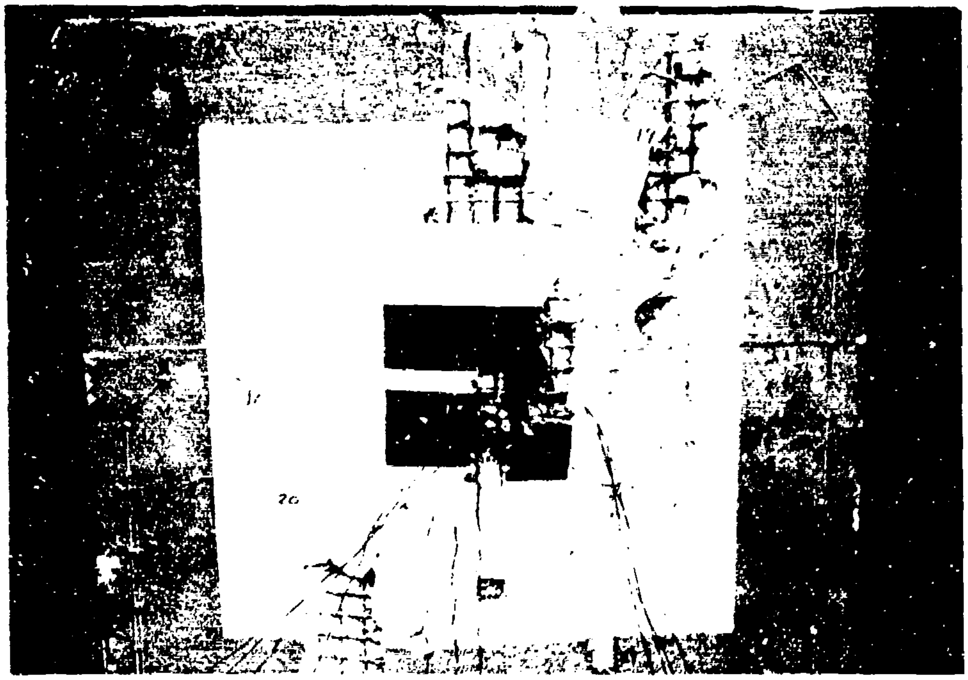


Figure 73. Test 16 Charge Side Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge).

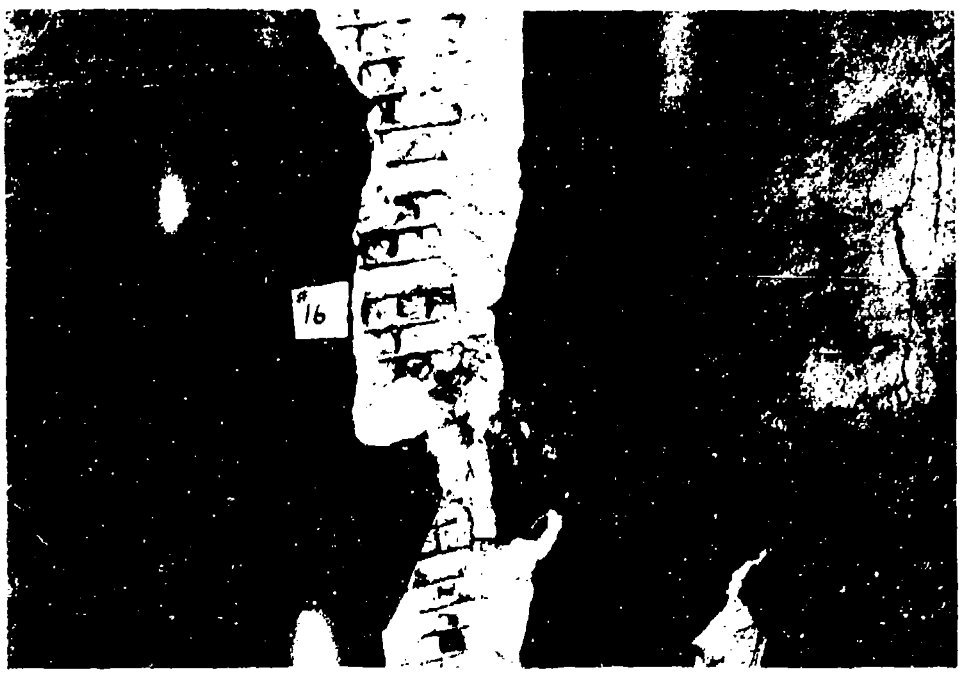


Figure 74. A Schematic of Test 16 Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge).

3. Type C Panel Tests

a. Test 17

Test 17 was conducted using the 2.7-pound cased charge against a reinforced SIFCON panel without instrumentation. The test panel was mounted in the concrete reaction structure and the cased charge was positioned at the correct standoff. The charge was initiated using a pulse from the high-speed camera used to record the wall failure pattern. Post-test inspection of the wall showed that the wall had suffered very slight damage which was confined to the area directly behind the cased charge. The wall did have a vertical crack, however, and the wall rotation was 0.75 inches A section of the SIFCON wall was rotated out from the back face as shown in Figure 75 and very fine pieces of the wall were ejected. The material ejected was not distinguishable in the high-speed films as fragments and velocities were not measured. Figure 76 shows a closeup of the back face. Figure 77 shows charge side damage. A schematic of wall damage is shown in Figure 78.

b. Test 18

Test 18 was also conducted on the Type C panel. An equivalent bare charge (replicating the 2.7-pound cased charge) which was 2.4 pounds of C4 at a standoff of 6 inches was used. The wall was bolted to the reaction structure. The charge was remotely detonated using the RP-83 detonator. The wall sustained only a minimal amount of damage limited to the area directly behind the charge. This damage consisted of cracks in the wall and a slightly raised portion as shown in Figure 79. A 2-inch rotation was measured and is shown in Figure 80. No measurable fragments were seen in the high-speed films. The wall damage was documented and photographed and the wall was removed. Figure 81 shows a close up of back face damage. Figure 82 shows charge side damage. A schematic of the damage is also shown in Figure 83.

c. Test 19

This test involved the 2.4-pound cased charge. The cased charge was positioned 6 inches from the reinforced SIFCON wall and detonated remotely using the high-speed camera to initiate the detonator. The outputs of the piezoresistive shock pressure gages and the piezocrystals were recorded on magnetic tape for processing after the test. A post-test inspection of the wall showed that the wall had sustained major damage with a breach approximately 12 inches wide by 8 inches high as shown in Figure 84. The spall area was 24 inches wide by 13 inches high. The wall suffered some vertical cracks and rotated approximately 0.875 inches as shown in Figure 85. Damage to the charge side of the wall indicated a very directional casing fragment spray. The high-speed film from the fragment camera showed that the high velocity fragments

Figure 75. Test 17 Wall Damage (Type C, 2.7-Pound Cased Charge).

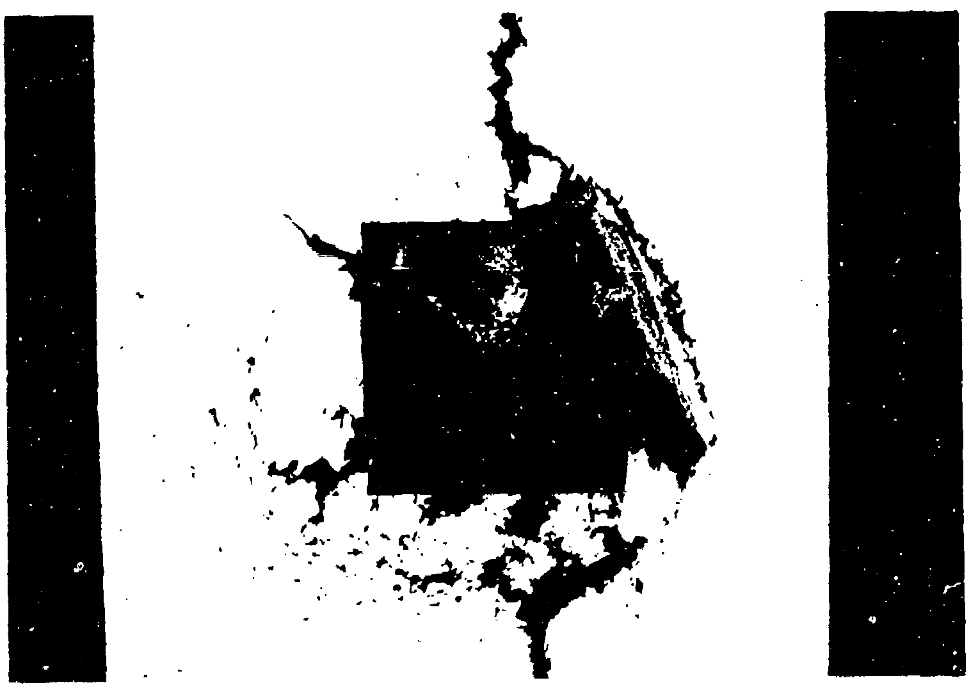


Figure 76. Test 17 Wall Damage Detail (Type C, 2.7-Pound Cased Charge).

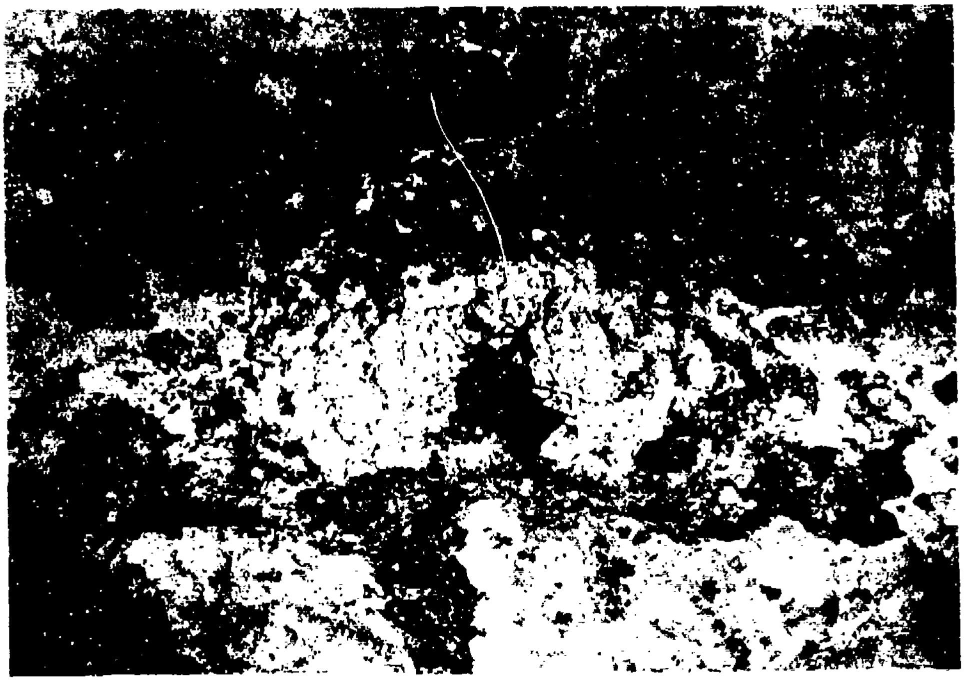
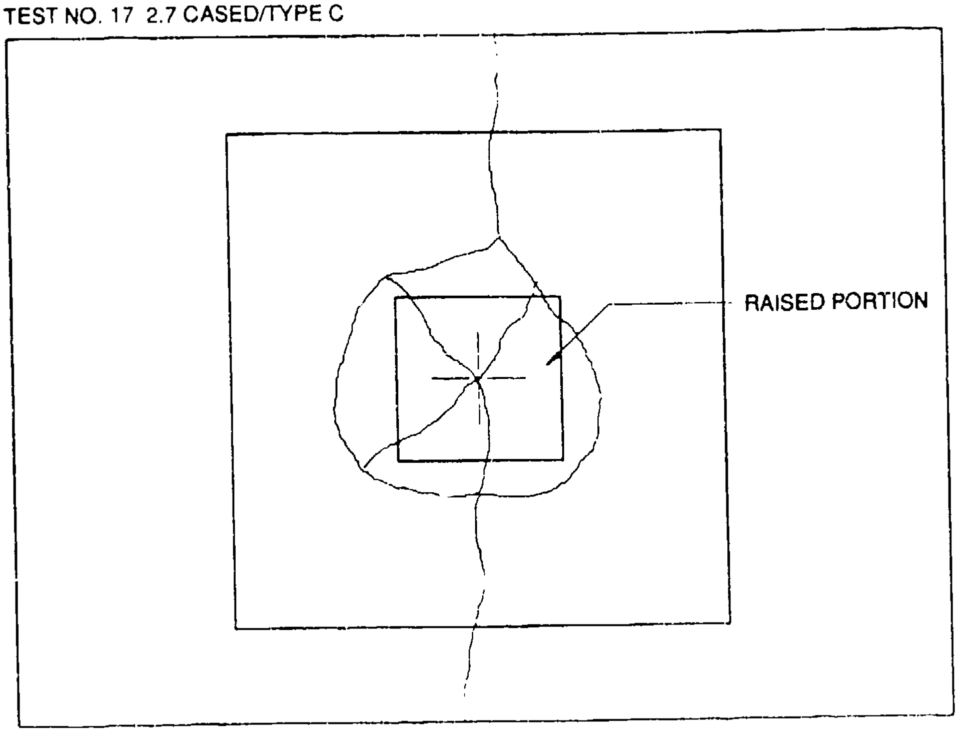


Figure 77. Test 17 Charge Side Wall Damage (Type C, 2.7-Pound Cased Charge).

TEST NO. 17 2.7 CASED/TYPE C



3/4" ROTATION

Figure 78. A Schematic of Test 17 Wall Damage (Type C, 2.7-Pound Cased Charge).

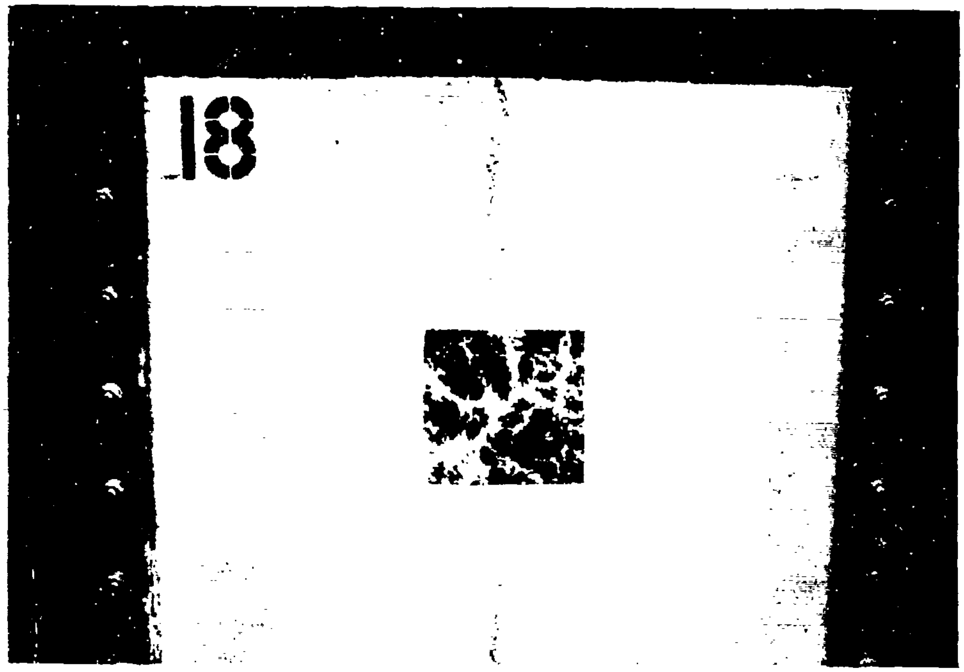


Figure 79. Test 18 Wall Damage (Type C, 2.4-Pound Equivalent Charge).

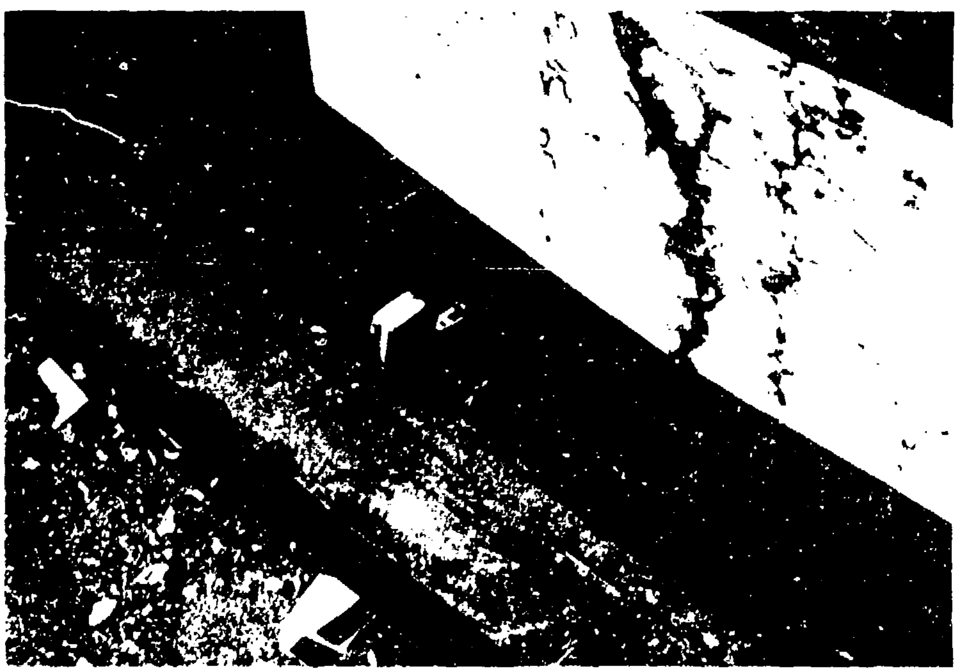


Figure 80. Test 18 Wall Rotation (Type C, 2.4-Pound Equivalent Charge).

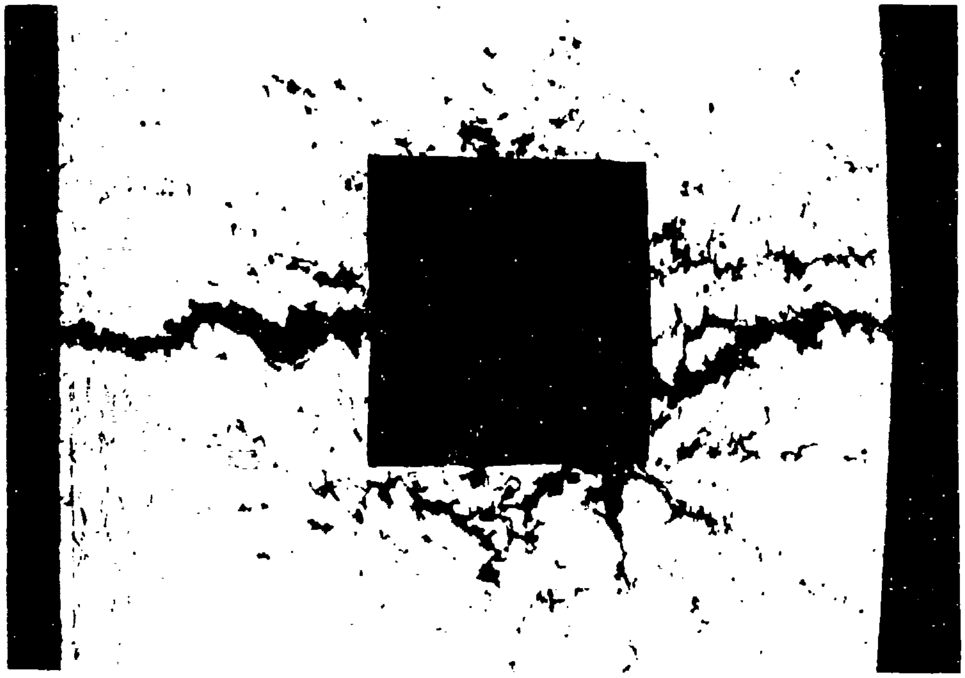


Figure 81. Test 18 Wall Damage Detail (Type C, 2.4-Pound Equivalent Charge).

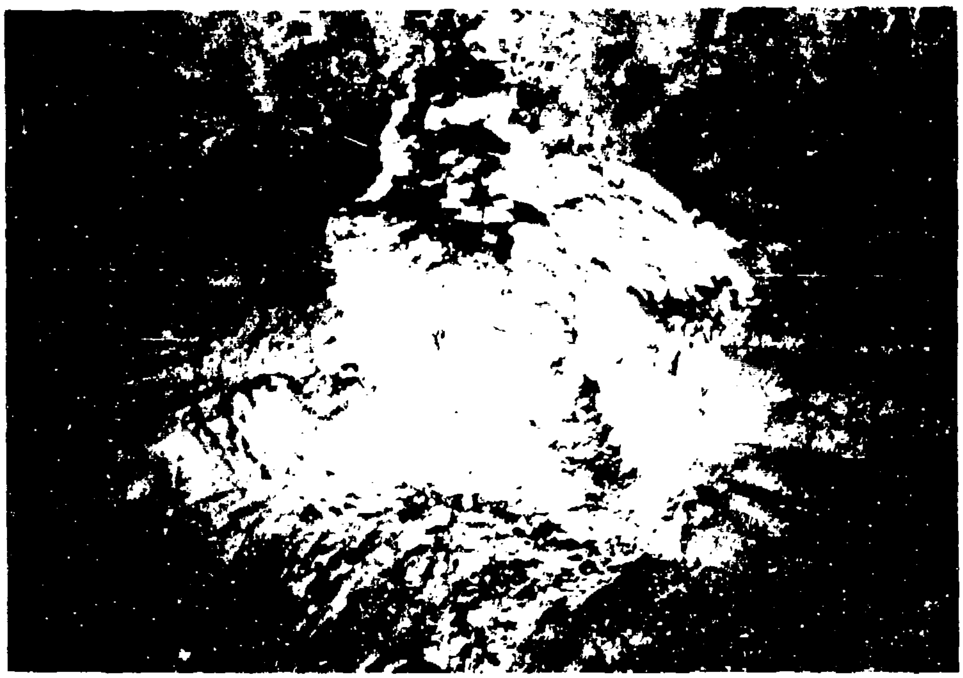


Figure 82. Test 18 Charge Side Wall Damage (Type C, 2.4-Pound Equivalent Charge).

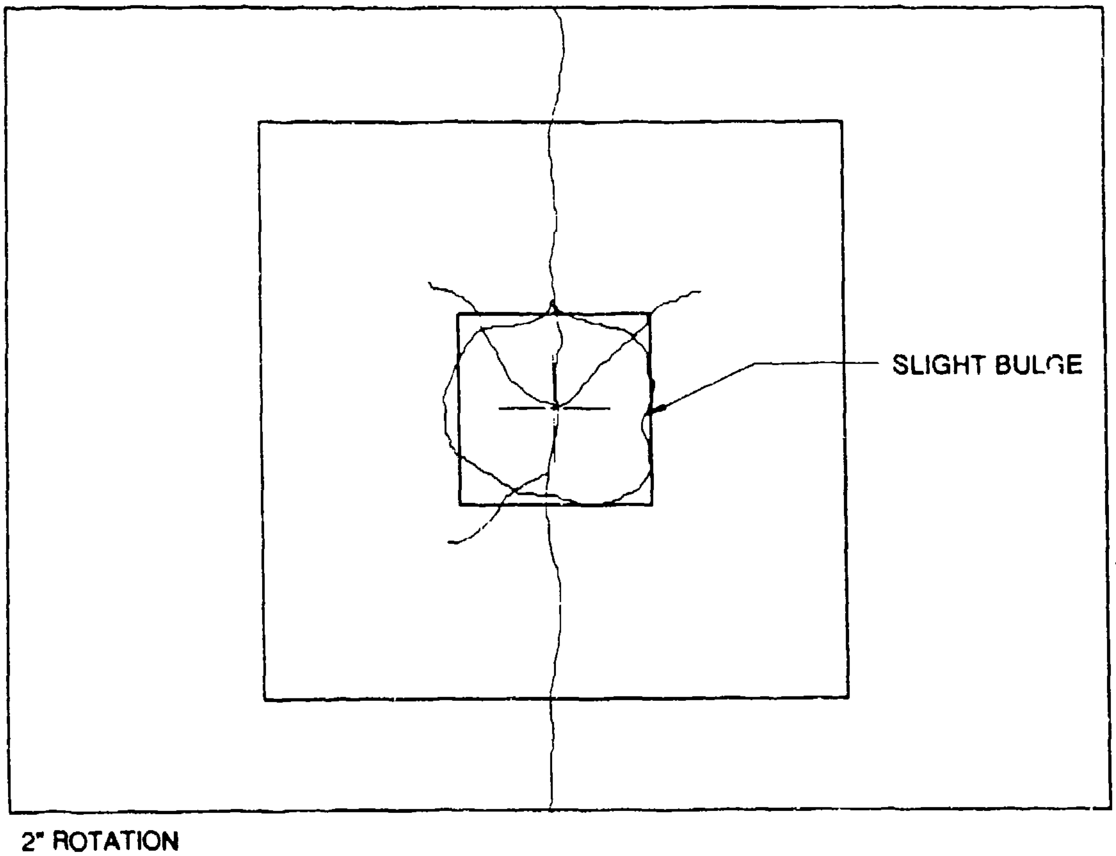


Figure 83. A Schematic of Test 18 Wall Damage (Type C, 2.4-Pound Equivalent Charge).

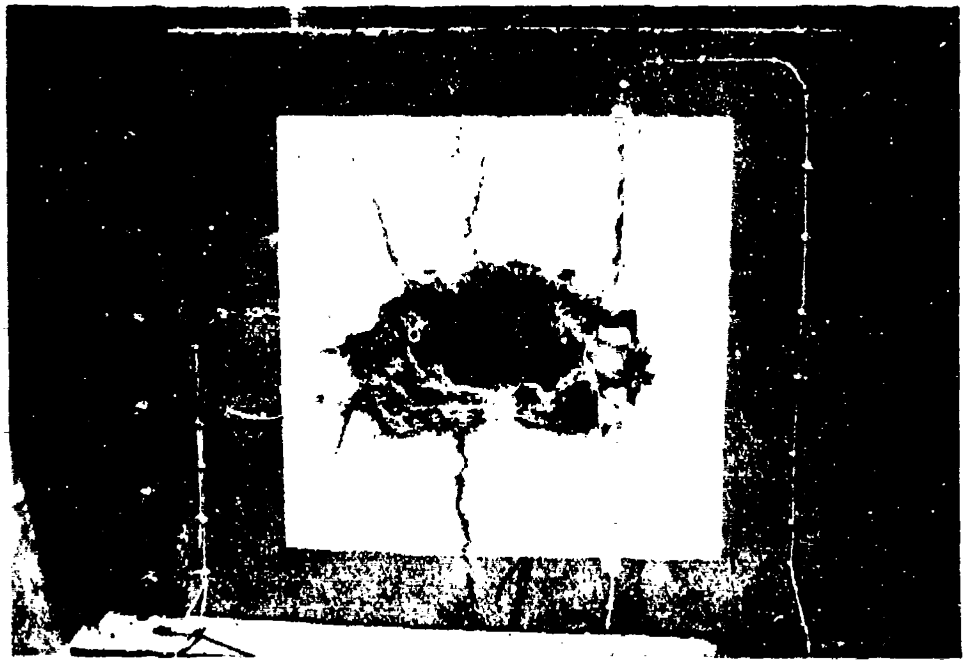


Figure 84. Test 19 Wall Damage (Type C, 2.4-Pound Cased Charge).

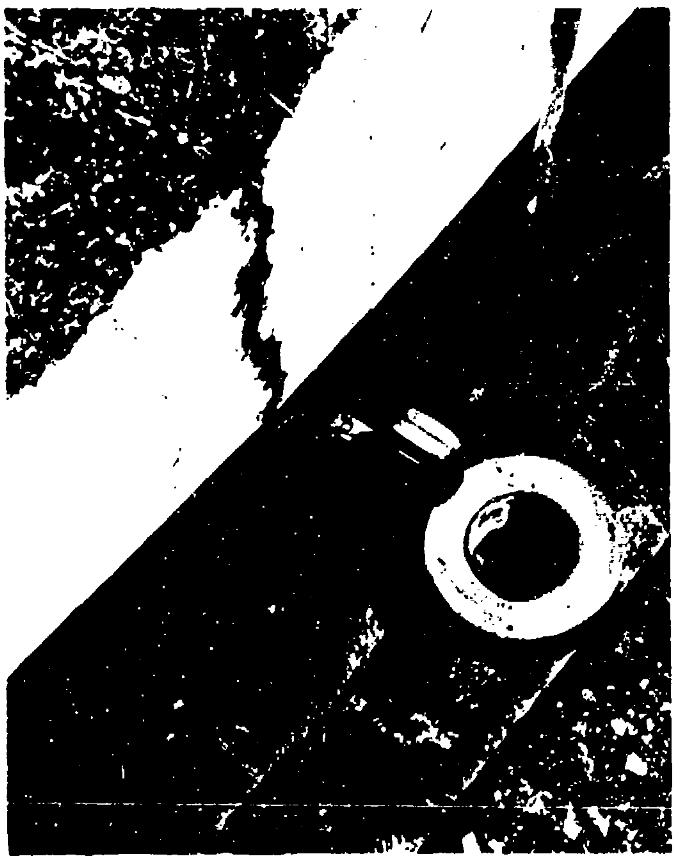


Figure 85. Test 19 Wall Rotation (Type C, 2.4-Pound Cased Charge).

were traveling at a velocity of approximately 288 fps. The rear face debris formed a hemispherical pattern. The slower fragments, shown in Figure 86, were traveling at a velocity of 70 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. Figure 87 shows charge side damage. A schematic of the wall failure is shown in Figure 88.

d. Test 20

Test 20 was conducted on the instrumented Type C panel using the equivalent bare charge (replicating the 2.4-pound cased charge) of 2.8 pounds of C4 at a standoff of 7 inches The wall was bolted to the reaction structure and the bare cylindrical charge positioned. The charge was remotely detonated using the RP-83 detonator which was initiated by a pulse from the high-speed camera used to record the wall failure mechanism. The damage suffered by the wall was considerably less than the cased charge test with no significant breaches or failures, as shown in Figure 89. The actual wall damage is more of a petaline of the back face as is usually found in metal targets rather than a spall failure as is normally found in reinforced concrete walls. The wall did sustain a vertical crack and rotated approximately 1.25 inches. Damage to the charge side of the wall is shown in Figure 90. The high-speed film showed that very few fragments were ejected and the faster fragments were traveling at a velocity of 105 fps. The carbon gage data and the crystal data was processed and plots of the data are included in Appendix C. A closeup of back face damage is shown in Figure 91. Figure 92 shows a schematic of wall damage.

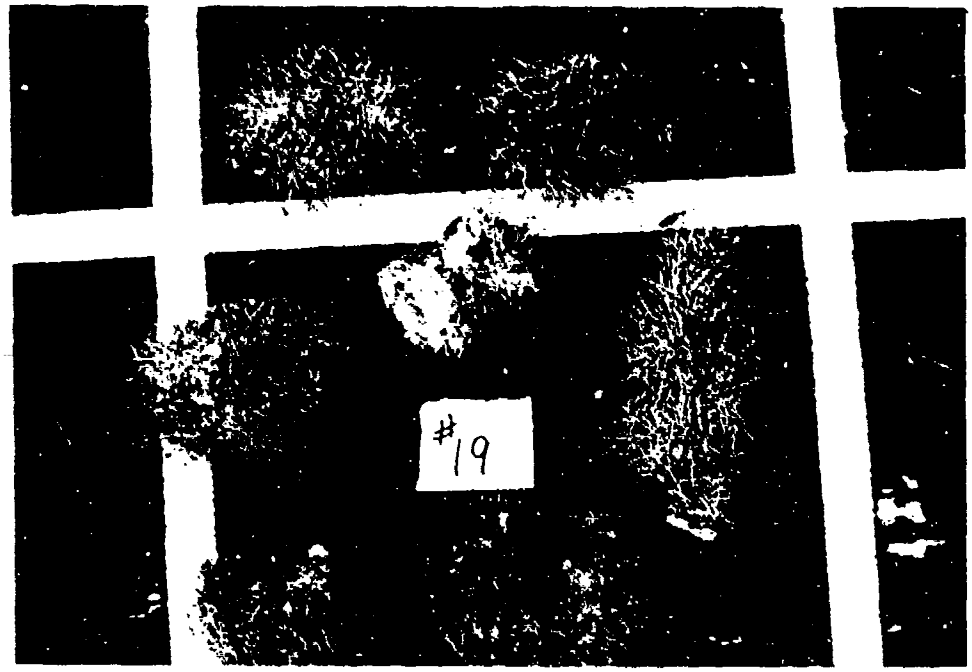


Figure 86. Test 19 Wall Debris (Type C, 2.4-Pound Cased Charge).

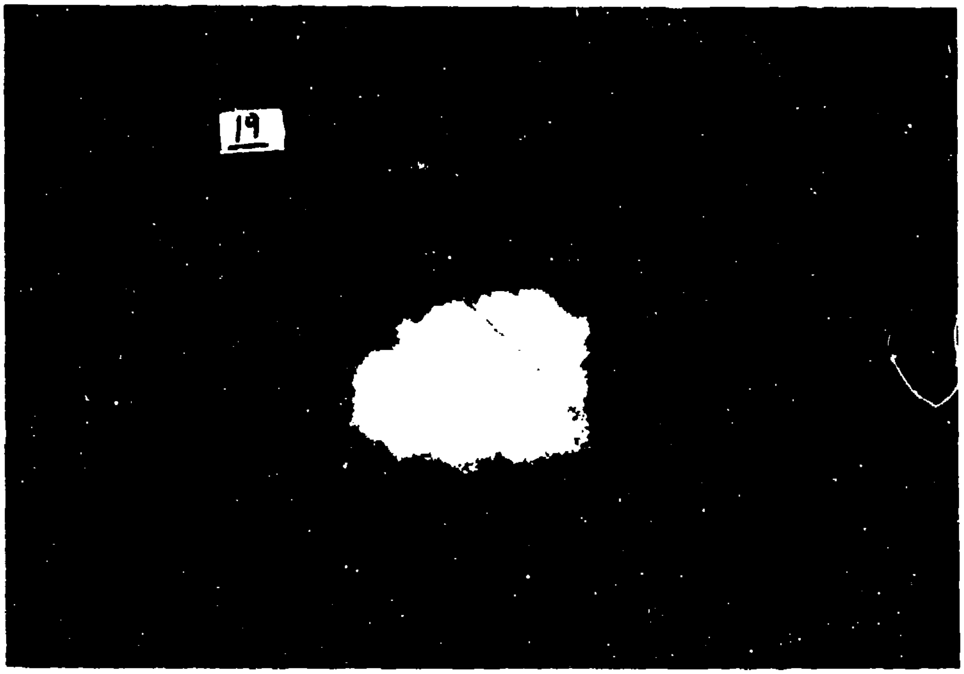


Figure 87. Test 19 Charge Side Wall Damage (Type C, 2.4-Pound Cased Charge).

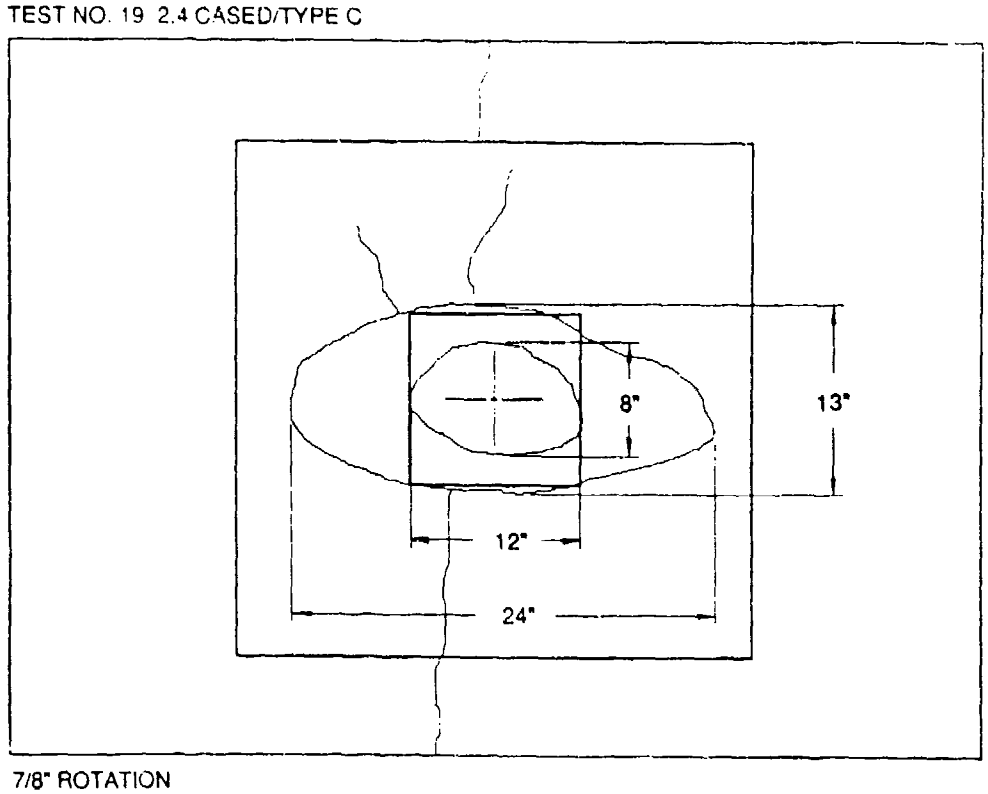


Figure 88. A Schematic of Test 19 Wall Damage (Type C, 2.4-Pound Cased Charge).

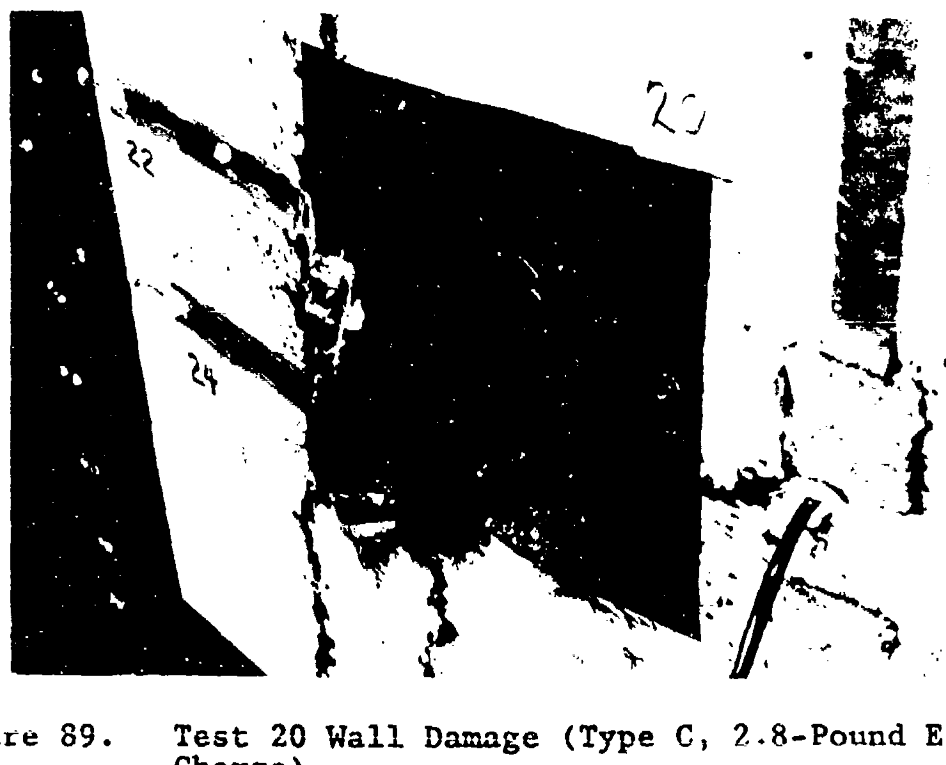


Figure 89. Test 20 Wall Damage (Type C, 2.8-Pound Equivalent Charge).

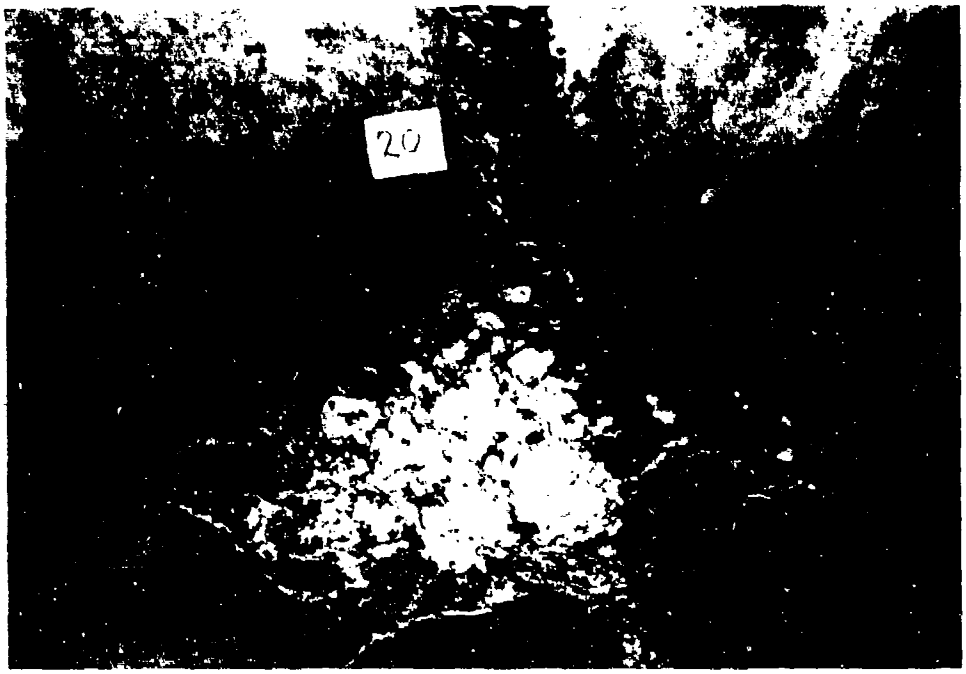


Figure 90. Test 20 Charge Side Wall Damage (Type C, 2.8-Pound Equivalent Charge).

Figure 91. Test 20 Wall Damage Detail (Type C, 2.8-Pound Equivalent Charge).

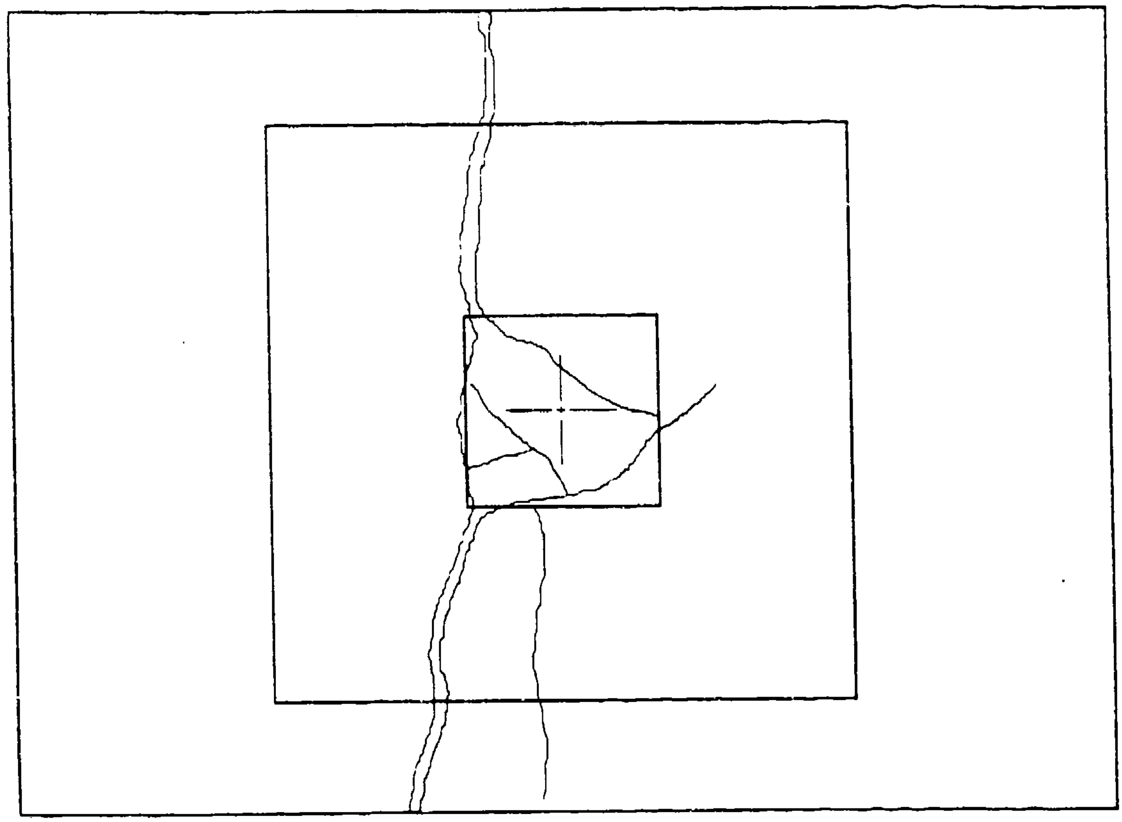


Figure 92. A Schematic of Test 20 Wall Damage (Type C, 2.8-Pound Equivalent Charge).

SECTION IV

ANALYSIS OF RESULTS

A. DISCUSSION OF RESULTS

As described previously, the loads tests were conducted for two principal reasons. First, the impulse plate fixture was shown to be a solid test device for load quantification for bare explosive tests. While the plate was not used to generate data later in the program for equivalent bare charges due to schedule and funding constraints, it can be effectively used in follow-on work. The second reason for the loads test concerned the quantification of cased charge airblast and fragment impulse. These test directly supported the panel testing effort.

1. Loads Tests

The bare charge tests and the cased charge tests were conducted to quantify the loads generated by the cased weapon for use in establishing an equivalent bare charge. In the bare charge tests conducted at SwRI, measurements of the side-on pressure, reflected pressure, and impulse distribution were made. The cased charge tests included measurements of the side-on pressure, reflected pressure, impulse distribution and fragment characterization, that is, fragment size, weight, and velocity. The combination of the bare charge data and the cased charge data were used to develop the equivalent bare charge. The following paragraphs provide a general discussion of the results of the loads tests.

a. Bare Charge Tests

The data measured in the bare charge tests have been summarized in TABLES 4 - 7 and includes the pressure data, integrated impulses, the impulse plug velocities and the calculated impulses on the plugs. This impulse data were calculated using the velocity data and the area of the plugs. The side-on pressure data are given in TABLE 4, gages number P1-P4. As can be seen in TABLE 4, the data vary considerably; however, this variation is because the gage positioning varied from test to test. Comparisons of the measured side-on pressures to a predicted side-on pressure yielded acceptable results. The reflected pressures are shown in locations P5-P12. The first three tests were conducted with a total of five reflected pressure gages, using PCB high pressure gages close to the charge. As can be seen in TABLE 4, gages failed in every test, primarily close in to the charge at the very high pressure areas (locations 8 and 10). Tests 4 and 5 were conducted using a larger number of gages. These tests also had a significant number of gage failures. A comparison of the reflected pressures for the five tests shows a fairly good agreement between the tests conducted

using the same charge weight. Tests 2 and 4 both involved 2.7 pounds of C4 and as shown in TABLE 4, the recorded pressures at locations 9, 10, and 12 show good agreement. Similarly, Tests 1 and 3, used the 2.4-pound charge and show good agreement at location P9 and Tests 3 and 5 show good agreement at locations P11 and P12. The integrated impulse data are presented in TABLE 5 and shows the same trends.

The impulse plug velocity data are summarized in TABLE 6. A comparison of the 2.4-pound tests (Tests 1, 3 and 5) shows a considerable variation especially in the results of Test 1. This variation is due in part to the fact that Test 1 used the fiber optic break wires while Tests 3 and 5 used the position transducers. Similarly, Test 2 used the fiber-optic break wires while Test 4 used the position transducers. A comparison of the actual velocities measured in Test 3 to a predicted calculated impulse showed that for the plugs closest to the charge (Plugs 3-7) the measured velocities for four of the plugs were within 12 percent of the predicted. One of the velocities, that of Plug 5, was within 24 percent of predicted. Similarly, a comparison of the actual velocities measured in Test 5 to the predicted calculated impulse showed variations ranging from 11 percent from predicted for Plug 5 to 28 percent for Plug 3. The remaining plugs varied between 19 percent and 23 percent. The comparison of Test 4 (the 2.7 pound test) to the predicted velocities for that test showed a very good agreement between the measured and the predicted. Variations ranged from a maximum of 14.5 percent at Location 7 to a minimum of 0 percent at Location 3. Locations 4 and 6 were all within 9 percent of the predicted velocity and Location 5, which was directly in front of the charge, within 3.9 percent. The impulse acting on the plugs was calculated using the measured velocities and these impulses are summarized in TABLE 6. All predictions were made using the Tables presented in Reference 1.

b. Cased Charge Tests

The cased charge data have been summarized in TABLES 8 - 10 and they include the measured pressures, integrated impulses, plug velocity and casing fragment velocities as recorded by the break screens. A comparison of the measured side-on and reflected pressures to calculated pressures shows a relatively good agreement for Test 6. This agreement indicates that the airblast pressure is not significantly reduced by the light casing on the 2.7-pound charge. A direct comparison of the 2.7-pound bare charge and the 2.7-pound cased charge shows an average 35 percent reduction in side-on pressures. A comparison of impulse shows very little reduction due to casing effects.

Pressures and impulses were more dramatically reduced by the heavy casing of the 2.4-pound charge. TABLES 4, 5 and 10 show that pressures were reduced an average of 66 percent and impulse by 48 percent.

A comparison of the highest measured fragment velocities to a calculated "Gurney" velocity for the 2.7-pound cased charge and for the 2.4-pound cased charge showed reasonable agreement. The Gurney initial fragment velocity for the 2.7-pound cased charge was calculated to be 8079 fps while the highest measured velocity for Test 6 was 6906 fps. The Gurney initial fragment velocity for the 2.4-pound cased charge was 4815 fps and the highest measured velocity in Test 7 was 6757 fps.

2. Panel Tests

a. Response Mode

(1). Comparison of Bare and Cased Charge Responses

The tests conducted on the three types of wall construction using the cased charges and the equivalent bare charges demonstrated that the combination of the fragment impact loads and the blast pressure loads associated with the detonation of a cased charge were a more severe environment than that created by the blast loads from an equivalent bare charge. In all of the tests conducted on the reinforced concrete panels, the cased charges created larger breaches in the panels than did any of the corresponding equivalent bare charges. The cased charge tests also generated concrete debris traveling at higher velocities than did the debris created by the equivalent bare charges. The initial shapes of the failed material was also different for the two charges. The bare charges produced a conical material failure shape which indicated the initiation of the failure at a point. The cased charges, however, produced a failure pattern on the rear face of the slabs which was hemispherical in shape indicating a spall and breach initiation over a larger area due to higher stresses generated by the combination of the fragment and blast impulses. The total back face spall areas were approximately the same size for the cased and equivalent bare charge tests and the equivalent bare charge tests caused a larger amount of wall rotation at the midspan than did the cased charge tests. The following paragraphs present details on the analyses of the data for each of the panel types:

Tests on Panel-Type A - The tests conducted on the lighter reinforced concrete panel (Tests 9 - 12) demonstrated that the cased charges created significantly more breach damage to the panels than did the equivalent bare charges. TABLE 11 presents the maximum and the average velocities for the concrete debris generated by each of the tests with the exception of Test 9 which

had no debris velocity measurements. The debris for Test 10 which was the 2.7-pound equivalent bare charge test was measured at a velocity of 168 fps for the fastest fragments. The measured debris velocities for Test 11 (the 2.4-pound cased charge) and Test 12 (the 2.4-pound equivalent bare charge) are presented in TABLE 11 and show that the maximum debris velocity is much higher for the cased charge than for the bare charge, 336 fps for Test 11 and 140 fps for Test 12. TABLE 12 compares the damage to the panels and includes data on the breach size, the back face spall size and the midspan rotation. As shown in TABLE 12, the 2.7 -pound cased charge test (Test 9) created a breach in the test panel approximately 20 inches x 14 inches while the bare charge, Test 10 had a smaller breach of 14 inches x 7 inches. The spall area was relatively similar for both the cased charge (32 inches x 25 inches) and the bare equivalent charge (38 inches x 24 inches); however, the amount of rotation at the wall midspan was larger for the equivalent bare charge than for the cased charge, 8 inches as compared to 5.75 inches. Tests 11 and 12 yielded results similar to that obtained in Tests 9 and 10, with the cased charge creating much more damage to the panel than the bare charge. The breach area for the cased charge is 28 inches x 12 inches as compared to 14 inches x 8 inches for the bare charge. The area of the back face that spalled is very similar for the two tests, 32 inches x 21 inches for the cased charge and 36 inches x 34 inches for the bare charge. The rotation at the wall midspan was larger for the equivalent bare charge (7 inches) than the rotation for the cased charge (5.25 inches).

A comparison between the two cased charge tests, Test 9 and 11, shows that both the concrete spall velocity and the degree of damage are much higher for the thicker casing than for the thin casing.

Tests on Panel-Type B - Tests 13 - 16 were tests conducted on the heavier reinforced concrete panels. These tests also showed that the cased charge tests created significantly more breach damage to the panels than did the equivalent bare charges. The maximum concrete debris velocities given in TABLE 11 show that the 2.7-pound cased charge (Test 13) generated debris traveling at a velocity of 210 fps while the debris for the 2.7-pound equivalent bare charge (Test 14) was traveling at 140 fps. The 2.4-pound cased test (Test 15) generated debris traveling at a velocity of approximately 291 fps. The 2.4-pound equivalent bare charge (Test 16) involved a spherical charge rather than the cylindrical charges that were used on the other bare charge tests. The debris velocity for this spherical charge test was measured at 120 fps. The damage sustained by the panels is also presented in TABLE 12. As shown in TABLE 12, the 2.7-pound cased charge test (Test 13) created a breech in the test panel approximately 21 inches x 18 inches while the bare charge, Test 14 had a smaller breach of 14 inches x 10 inches. The spall area for both tests was very similar. The cased charge created a spall area of 32 inches x 25 inches and the

equivalent bare charge created a spall area of 38 inches x 24 inches. The panel rotation at the midspan was larger for the equivalent bare charge (2 inches) than for the cased charge which was 1.75 inches. The 2.4-pound cased charge and the 2.4-pound equivalent bare charge had different charge geometries and are discussed later in this section.

A comparison of Tests 13 and 15, the two cased charge tests, shows that the concrete debris velocity for the 2.4-pound cased charge was traveling at a much higher velocity than the debris for the 2.7-pound cased charge. Similarly, the degree of damage is much higher for the thicker casing than for the thin casing.

Tests on Panel-Type C - The tests conducted on the reinforced SIFCON panels, Tests 17 through 20 showed that the reinforced SIFCON panels sustained considerably less damage than the reinforced concrete panels, especially with the 2.7-pound cased and equivalent bare charge. As shown in TABLE 11, there were no measurable debris velocities for either the 2.7-pound cased charge or the 2.7-pound equivalent charge. The 2.4-pound cased and bare charge tests showed that the debris generated by the cased charge was traveling at much higher speeds than the debris for the 2.4-pound bare charge. The cased charge generated debris was traveling at a maximum velocity of 288 fps and the 2.4-pound equivalent bare charge generated debris was traveling at a slower velocity of 105 fps. The actual damage sustained by the reinforced SIFCON panels tested with the 2.7-pound cased charge consisted of several cracks in the panel and one corner of a small section of SIFCON fibers separating from the wall. The panel rotated 0.75 inches at the midspan. The 2.7-pound equivalent bare charge caused even less damage with the wall having only a slight bulge in the center, but did cause a larger rotation of approximately 2 inches. These tests did show that even though the damage caused was minor, the cased charge created more damage than the equivalent bare charge. The tests with the 2.4-pound cased charge and the 2.4-pound bare charge further demonstrated the difference in damage mechanisms between the cased and bare charges. The 2.4-pound cased charge test resulted in a 12 inch x 8 inch breach and a 24 inch x 13 inch spall area while the 2.4-pound equivalent bare charge had no breach or spall area. As in the previous tests, the bare charge test resulted in a larger panel rotation (1.25 inches) than did the cased charge (0.875 inches).

As was the case with the reinforced concrete tests, the comparison of the two cased tests, the 2.7-pound cased and the 2.4-pound cased, showed that the thicker casing of the 2.4-pound cased charge caused considerably more damage than the thinner case.

(2). Comparison of Spherical and Cylindrical Charges

As previously mentioned, Test 16 which was the 2.4-pound equivalent bare charge test, using a spherical charge instead of a cylindrical charge. The purpose of this test was to determine what effects charge shape would have on the damage mechanisms. The spherical shaped charge test showed that shape does affect the damage mechanisms since the panel tested using the spherical bare charge sustained only minor damage, consisting primarily of several cracks in the panel with no breach or major spall. In all of the previous tests, the cased charges and their corresponding equivalent bare charges caused some type of breach in the panels (see TABLE 12) even though the cased charges did cause the larger breaches. In addition, the spall areas for the cased and the bare charge tests were very similar in size. Since Test 15 (the 2.4-pound cased charge) resulted in damage to the panel consisting of a 28 inch x 24 inch breach area and a 35 inch x 41 inch spall area, considerably more damage was expected from the 2.4-pound spherical bare charge than was found. The reduction in the amount of damage to the panel in Test 16 cannot be attributed to the heavier reinforcement, because the 2.7-pound cased and the 2.7-pound equivalent bare charge tests conducted on the same heavier reinforced panel construction (Tests 13 and 14) both resulted in breaches and in sizable spall areas. The reduction in the damage to the test panel has to be attributed to the spherical shape of the charge which, in effect, reduces the area of the explosive which is in near contact with the panel.

b. Pressures and Pressure Decay

TABLES 16 and 17 contain reduced data from the carbon stress gage measurements and piezocrystal measurements made in Tests 13 through 16 and 19 and 20. While interpretation of these data are difficult, some discussion is provided in the paragraphs below.

The first comparison that can be made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. TABLE 16 shows that the heavily cased charges (2.4-pound cased) in Tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7-pound cased, Test 13) by a factor of 1.7 in the Type B panel. Additionally, the heavily cased charge produced stresses four times higher than the equivalent bare charge for Type B. In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance. CG2 in the SIFCON shows an increase of 4.5 times over the equivalent bare charge.

Attenuation of the stress is also difficult to analyze because of gage location effects (carbon stress gages were not located directly behind one another). It should be noted, however, that attenuation is significantly larger in the equivalent charge tests (14, 16 and 20) than in the cased charge tests.

Last, time-of-arrival data are troublesome. The piezocrystal responses are omnidirectional and apparently responded to both through thickness and lateral wave propagation. These gages can be used more successfully in future work by isolating the gage sides from the stress pulse such that their responses are unidirectional.

c. Data Analysis and Comparison with Existing Data

Data from reference 21 were reviewed and combined with data generated in this test program to assess the local effects of blast and fragments on breach and spall. TABLE 18 presents these data along with calculations made for adjusted charge weight, scaled spall diameter, breach diameter and applied impulse rate. The charge weights of all of the explosive charges considered in the table and in Figures 93-96 were adjusted first according to surface conditions (ground or free air), second by aspect ratio of the charge to account for enhanced effects of cylinders at small standoffs, and finally according to casing effects by increasing the charge weight linearly as a function of charge weight to case weight ratio. Aspect ratio effects were considered to be negligible at scaled standoffs greater than 1.0 $ft/lb^{1/3}$, and were a maximum of the square root of the aspect ratio times the charge weight at very small standoffs. Casing effects were considered to be negligible at standoffs greater than a standoff to case diameter ratio of 10.0, and were a maximum of $\frac{(W+C)}{W}$ times the charge weight at very small standoffs.

The relationships developed and presented in TABLE 18 are estimates of the true interactions at small standoffs, but are reasonable, and serve to illustrate the trends of spall and breach diameter shown in Figures 93 and 94. The objective of future research in the combination of blast and fragment loads will be to define the true relationships between fragment density and generated stress, and the resulting structural damage and breach. Figures 95 and 96 show the effect of load rate on spall diameter and breach diameter for given charge weights. Measured stresses and durations from tests reported in the previous sections as well as those presented in Reference 21 were used to generate a load rate, which is simply the rate of application of impulse or one-half the peak stress value for a triangular load. The point here is that the combined blast and impact (fragment) loads produced much shorter pulses (a higher rate) and larger or greater damage.

B. EVALUATION OF EXISTING PREDICTIVE TECHNIQUES

Three techniques for local breach prediction were reviewed for applicability for prediction of breaching responses in reinforced concrete.

1. Severe Dynamic Loads (Krauthammer) Code

The techniques presented and the code described in the references reviewed (References 17 and 18) do not truly consider breaching response in concrete structures. Localized loads are considered, but only to predict shear response and flexural response. One calculation with this code was made for the 2.7-pound charge and the Type A panel. A maximum displacement of 1.2 inches was predicted with no local breach. A rotation of 5.75 inches was achieved in Test 9. Data from the analysis are included in Appendix H.

2. WES Code

The techniques presented in Reference 19 do not specifically address breach; however, some details of localized, nonuniform loading presented are more complete than those considered in the other codes. No calculations were made since breach was not considered.

3. REICON

The REICON code (Reference 20) was exercised for all cases tested. This code considers localized loading and breaching as well as charge shape effects. Comparisons of REICON predictions and test values are presented in TABLE 19. It can be seen that the casing effects (not considered in REICON) cause some disparity to occur between predicted and actual results. Output from code runs is included in Appendix I.

TABLE 18. SCALED SPALL DIAMETER, BREACH DIAMETER, AND LOAD RATE VERSUS SCALED RANGE.

Seq	Ref	Test No	R (in)	W TNT (lb)	Chg Len (in)	Chg Dia (in)	Aspect	Pred ir (psi-ms)	Impulse Increase (%)	Adj Impulse (psi-ms)	Equiv W (lb)	Case Thk. (in)	Case Wt. (lb)	R/W^1/3 (adj) (ft/lb^.3)	R/W^1/3* W/(W+C) (ft/lb^.3)	T (in)	f'c (psi)
1	McVay	1c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0	0.000	0.069580759	0.069580759	8.50	5090
2	McVay	1d	18.5	10.195	11.44	3.81	3.00	389.25951	4.1797721	405.52967	11.00	0	0.000	0.693148317	0.693148317	8.50	5090
3	McVay	2c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0.047	0.490	0.069580759	0.054146957	8.50	4850
4	McVay	3a	29.25	40.295	18.25	6	3.04	389.26023	4.3442843	406.1708	43.61	0	0.000	0.69247078	0.69247078	8.50	5080
5	McVay	3b	18.5	10.195	11.25	3.75	3.00	389.25951	3.118038	401.39677	10.80	0.088	3.223	0.697560957	0.537170953	8.50	5080
6	McVay	4b	29.25	19.719	14.25	4.75	3.00	267.49615	1.4181019	271.28951	20.27	0.111	6.524	0.894035268	0.676323103	8.50	3290
7	McVay	5a	18.5	9.702	11.25	3.75	3.00	379.06954	4.0218782	394.31526	10.44	0.088	3.223	0.705307379	0.538961713	8.50	13815
8	McVay	5b	18.5	4.968	9	3	3.00	266.9139	1.3993556	270.64897	5.10	0.07	1.641	0.895404494	0.677547876	8.50	13815
9	McVay	5c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0.047	0.490	0.069580759	0.054146957	8.50	13815
10	McVay	6c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0.047	0.490	0.069580759	0.054146957	8.50	4605
11	McVay	7c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0.047	0.490	0.069580759	0.054146957	8.50	5050
12	McVay	8c	18.5	4.968	9	3.03	2.97	266.9139	1.5098454	270.94389	5.11	0.21875	4.921	0.89477336	0.456041933	5.38	4000
13	McVay	10a	29.25	19.719	14.25	4.75	3.00	267.49615	1.4181019	271.28951	20.27	0.111	6.524	0.894035268	0.676323103	8.50	4300
14	McVay	10c	1	1.472	6	2	3.00	35990.576	13.439222	40827.43	1.72	0.047	0.490	0.069580759	0.054146957	8.50	4360
15	McVay	Box-2	18.5	4.966	9	3	3.00	266.85866	1.4005596	270.59618	5.10	0	0.000	0.895517611	0.895517611	11.25	5010
16	McVay	Box-3	18.5	4.966	9	3	3.00	266.85866	1.4005596	270.59618	5.10	0.21875	4.868	0.895517611	0.458263938	11.25	5010
17	McVay	Box-5	18.5	10.189	11.69	3.81	3.07	389.13672	4.9135947	408.25732	11.14	0.088	3.404	0.690278388	0.528717902	11.25	5010
18	McVay	Box-6	18.5	10.189	11.69	3.81	3.07	389.13672	4.9135947	408.25732	11.14	0.34275	12.351	0.690278388	0.327347574	11.25	5010
19	McVay	Box-7	24	16.44	17.5	3.94	4.44	331.38052	6.760798	353.78449	18.61	0	0.000	0.754758383	0.754758383	11.25	5010
20	McVay	Box-9	24	8.062	14.31	3.06	4.68	229.45508	0.08859[illegible]	229.65837	8.08	0.15625	5.772	0.996847673	0.581338511	11.25	5010
21	Ball		1.62	1	3.24	3.24	1.00	8792.4119	0	8792.4119	1.00	0	0.000	0.135000021	0.135000021	6.00	3500
22	Ball		2.04	2	4.08	4.08	1.00	8802.4793	0	8802.4793	2.00	0	0.000	0.134929114	0.134929114	6.00	3500
23	Ball		2.58	4	5.16	5.16	1.00	8730.1274	0	8730.1274	4.00	0	0.000	0.13544154	0.13544154	6.00	3500
24	Ball		3.54	10	7.08	7.08	1.00	8525.5135	0	8525.5135	10.00	0	0.000	0.136926903	0.136926903	6.00	3500
25	Ball		2.58	4	5.16	5.16	1.00	8730.1274	0	8730.1274	4.00	0	0.000	0.13544154	0.13544154	10.00	3500
26	Ball		3.54	10	7.08	7.08	1.00	8525.5135	0	8525.5135	10.00	0	0.000	0.136926903	0.136926903	10.00	3500
27	Ball		4.08	16	8.16	8.16	1.00	8802.4792	0	8802.4792	16.00	0	0.000	0.134929123	0.134929123	10.00	3500
28	Ball		4.5	21	9	9	1.00	8663.0398	0	8663.0398	21.00	0	0.000	0.135922582	0.135922582	10.00	3500
29	Ball		6	50	12	12	1.00	8691.0679	0	8691.0679	50.00	0	0.000	0.135720921	0.135720921	20.00	3500
30	Coltharp	1	--	47.95	--	--	--	ERR	0	ERR	ERR	0	0.000	ERR	ERR	20.00	3500
31	Coltharp	2	--	47.95	--	--	--	ERR	0	ERR	ERR	0	0.000	ERR	ERR	8.00	3500
32	Kropatscheck	1	59.05	76.24	25.59	7.87	3.25	182.92428	0	182.92428	76.24	0.236	40.989	1.160498199	0.754729019	12.80	6817
33	Kropatscheck	2	33.46	15.673	19.85	4.13	4.81	194.30822	0	194.30822	15.67	0.197	13.674	1.114193787	0.595049491	12.80	6817
34	Marchand	9	6	2.7	10.7	2.51	4.26	1252.1251	45.519594	1822.0873	4.96	0.0697	1.618	0.293245363	0.221080183	4.00	5890
35	Marchand	10	6	2.4	10.7	2.23	4.80	1166.1528	40.321698	1636.3654	4.17	0	0.000	0.310530497	0.310530497	4.00	5890
36	Marchand	11	6	2.4	7.54	3.256	2.32	1166.1528	43.296243	1671.0531	4.32	0.302	5.980	0.307065264	0.128738672	4.00	5890
37	Marchand	12	7	2.8	7.54	2.87	2.63	970.36246	20.220482	1166.5744	3.81	0	0.000	0.373375688	0.373375688	4.00	5890
38	Marchand	13	6	2.7	10.7	2.51	4.26	1252.1251	45.519594	1822.0873	4.96	0.0697	1.618	0.293246363	0.221080183	4.00	5890
39	Marchand	14	6	2.4	10.7	2.23	4.80	1166.1528	40.321698	1636.3654	4.17	0	0.000	0.310530497	0.310530497	4.00	5890
40	Marchand	15	6	2.4	7.54	3.256	2.32	1166.1528	43.296243	1671.0531	4.32	0.302	5.980	0.307065254	0.128738672	4.00	5890

TABLE 18. SCALED SPALL DIAMETER, BREACH DIAMETER, AND LOAD RATE VERSUS SCALED RANGE (CONTINUED).

Seq	Ref	Test No	Rebar Spg (Avg.) (in)	P v (per face)	Spall Avg. Dia. (in)	Spall Depth (in)	Breach Avg. Dia. (in)	Meas. Peak (psi)	Meas. Duration (ms)	Meas. Spall Vel. (ips)	Ds bar	Db bar	Adjusted Sc. Range	I dot
1	McVay	1c	5.5	0.0035	19.15	2.5	0	12200	0.15	636	30.75	0.00	0.0695808	87.67
2	McVay	1d	5.5	0.0035	14.35	2.25	0	--	--	336	2.37	0.00	0.6931483	ERR
3	McVay	2c	5.5	0.0035	20.75	2.25	0	14500	0.14	684	33.32	0.00	0.054147	133.89
4	McVay	3a	5.5	0.0035	32.50	8.5	0	7350	0.135	828	5.38	0.00	0.6924708	5.31
5	McVay	3b	5.5	0.0035	19.20	1.38	0	7350	0.055	468	3.18	0.00	0.537171	6.84
6	McVay	4b	5.5	0.0035	16.50	1.81	0	3500	0.107	528	2.15	0.00	0.6763231	2.59
7	McVay	5a	5.5	0.0035	26.65	3.75	0	23300	0.045	--	4.34	0.00	0.5389617	21.62
8	McVay	5b	5.5	0.0035	12.25	1.06	0	5350	0.046	204	1.60	0.00	0.6775479	3.95
9	McVay	5c	5.5	0.0035	21.50	4.38	0	61000	0.073	1068	34.53	0.00	0.054147	563.28
10	McVay	6c	5.5	0.0035	14.55	3.75	0	--	--	528	23.37	0.00	0.054147	ERR
11	McVay	7c	5.5	0.0035	9.00	2	0	--	--	420	14.45	0.00	0.054147	ERR
12	McVay	8c	4.3125	0.0035	--	--	7.44	--	--	780	0.00	1.53	0.4560419	ERR
13	McVay	10a	1.375	0.0035	6.50	1.25	0	14800	0.135	444	0.85	0.00	0.6763231	10.94
14	McVay	10c	1.375	0.0035	13.25	0.62	0	32920	0.152	840	21.28	0.00	0.054147	303.99
15	McVay	Box-2	8	0.0157	8.50	2.5	0	--	--	--	0.84	0.00	0.8955176	ERR
16	McVay	Box-3	8	0.0157	18.00	3	0	--	--	--	1.77	0.00	0.4582639	ERR
17	McVay	Box-5	8	0.0157	27.50	3.75	0	--	--	--	3.44	0.00	0.5287179	ERR
18	McVay	Box-6	8	0.0157	35.00	3.25	0	--	--	--	4.37	0.00	0.3273476	ERR
19	McVay	Box-7	8	0.0157	31.50	3	0	--	--	--	3.56	0.00	0.7547584	ERR
20	McVay	Box-9	8	0.0157	30.00	3	0	--	--	--	2.67	0.00	0.5813385	ERR
21	Ball		11.875	0.00372	17.40	2.4	0	--	--	--	21.48	0.00	0.135	ERR
22	Ball		11.875	0.00372	--	--	18.36	--	--	--	0.00	22.68	0.1349291	ERR
23	Ball		11.875	0.00372	--	--	[illegible]	--	--	--	0.00	32.49	0.1354415	ERR
24	Ball		11.875	0.0066	--	--	[illegible]	--	--	--	0.00	35.06	0.1369269	ERR
25	Ball		11.875	0.0066	10.20	5.76	0	--	--	--	7.53	0.00	0.1354415	ERR
26	Ball		11.875	0.0066	--	--	38.28	--	--	--	0.00	27.96	0.1369269	ERR
27	Ball		11.875	0.0066	--	--	42.72	--	--	--	0.00	31.66	0.1349291	ERR
28	Ball		11.875	0.0066	--	--	47.52	--	--	--	0.00	34.96	0.1359226	ERR
29	Ball		11.375	0.00693	--	--	68.28	--	--	--	0.00	25.15	0.1357209	ERR
30	Coltharp	1	12	0.0018	--	--	28	--	--	--	ERR	ERR	ERR	ERR
31	Coltharp	2	12	0.005	--	--	26	--	--	--	ERR	ERR	ERR	ERR
32	Kropatscheck	1	--	0.00166	--	--	42.35	--	--	--	0.00	2.85	0.754729	ERR
33	Kropatscheck	2	--	0.00166	25.60	6.7	0	--	--	--	1.80	0.00	0.5950495	ERR
34	Marchand	9	3	0.004	--	--	17	--	--	--	0.00	11.84	0.2210802	ERR
35	Marchand	10	3	0.004	--	--	10.5	--	--	840	0.00	7.03	0.3105305	ERR
36	Marchand	11	3	0.004	--	--	20	--	--	912	0.00	13.39	0.1287387	ERR
37	Marchand	12	3	0.004	--	--	11	--	--	840	0.00	6.64	0.3733757	ERR
38	Marchand	13	1.5	0.0182	--	--	19.5	34467	0.015	720	0.00	13.58	0.2210802	77.95
39	Marchand	14	1.5	0.0182	--	--	12	7250	0.08	624	0.00	8.03	0.3105305	11.67
40	Marchand	15	1.5	0.0182	--	--	26	--	--	912	0.00	17.41	0.1287387	ERR

TABLE 19. COMPARISONS BETWEEN REICON CODE PREDICTIONS AND TEST MEASUREMENTS FOR PANEL TESTS 9 - 20.

Test	Charge Weight	Panel Type	Predicted Breach[1] (inches)	Actual Breach[2] (inches)	Predicted Rotation (inches)	Actual Rotation (inches)
9	2.7	A	21.5	17.0	9.69	5.75
11	2.4	A	19.0	20.0	7.38	5.25
13	2.7	B	13.4	19.5	2.56	1.75
15	2.4	B	8.6	26.0	1.94	1.75
17	2.7	C	7.2	0.0	1.54	0.75
19	2.4	C	0.0	10.0	1.17	0.88

Notes:

1) Circular breach
2) Average of horizontal and vertical diameters measured

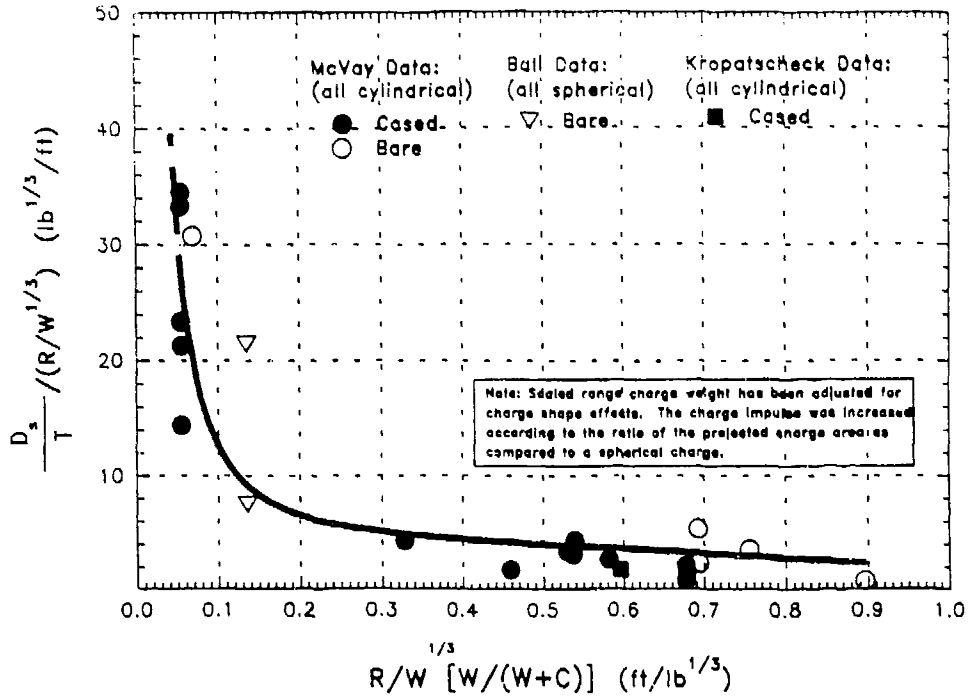


Figure 93. Scaled Spall Diameter versus Scaled Range.

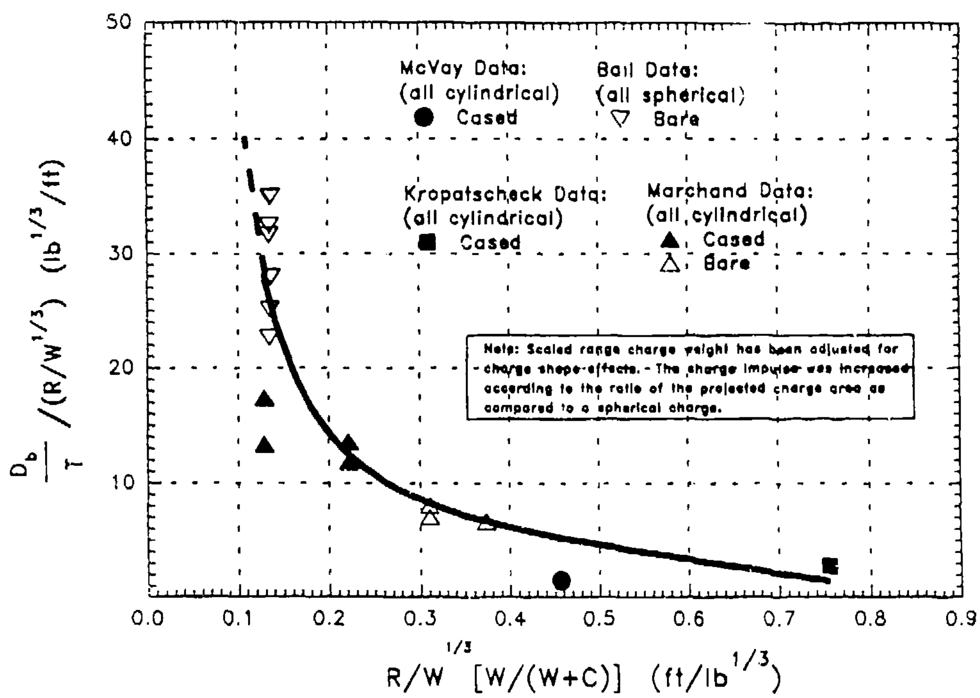


Figure 94. Scaled Breach Diameter versus Scaled Range.

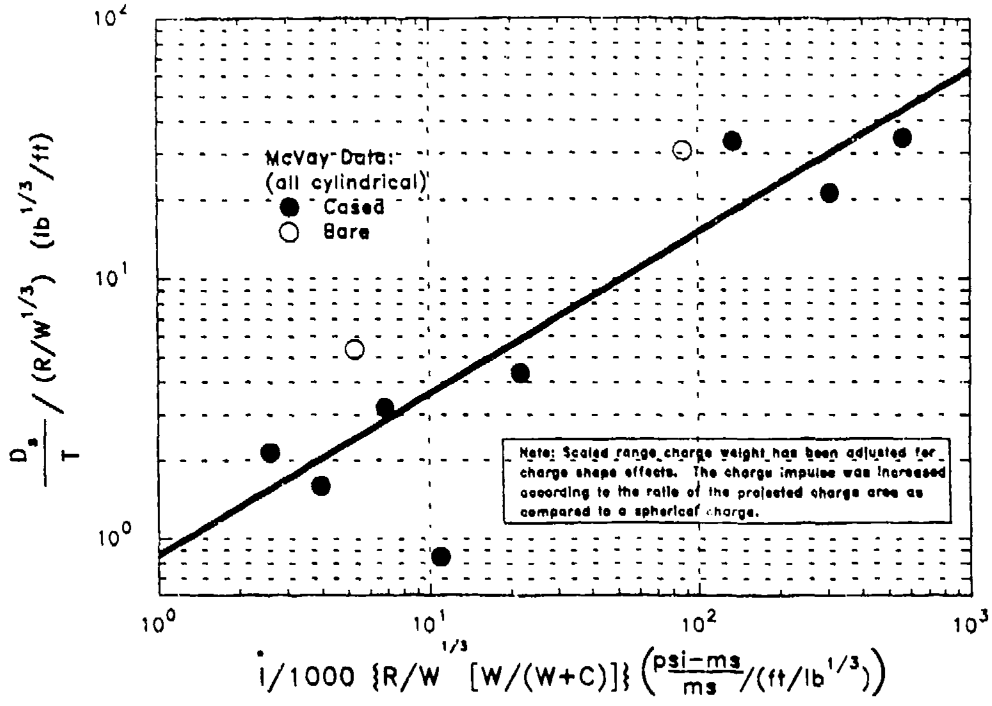


Figure 95. Scaled Spall Diameter versus Load Rate.

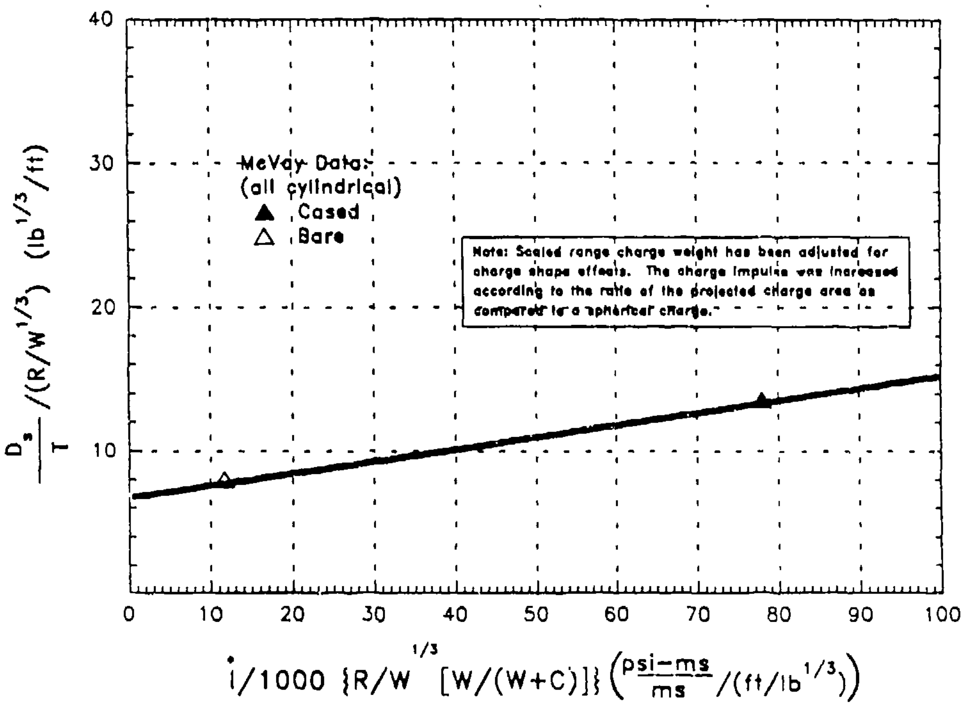


Figure 96. Scaled Breach Diameter versus Load Rate.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This report has documented the Phase I procedures used and tests conducted in support of the overall study concerning the synergism observed between blast and fragments for close in bomb loadings on common construction materials.

The results reported in the previous sections serve well to indicate the validity of the synergism in the described loadings. Increases in panel damage were observed, and loads were quantified and measured on the exterior and inside the tested structures to define the fragment effects. Increases in stresses internal to the panels were shown to be up to four times those observed for bare explosive charges.

Specifically, the tests conducted on the three types of wall construction using the cased charges and the equivalent bare charges demonstrated that the combination of the fragment impact loads and the blast pressure loads associated with the detonation of a cased charge were a more severe environment than that created by the blast loads from an equivalent bare charge. In all of the tests conducted on the reinforced concrete panels, the cased charges created larger breaches in the panels than did any of the corresponding equivalent bare charges. The cased charge tests also generated concrete debris traveling at higher velocities than did the debris created by the equivalent bare charges. The initial shapes of the failed material was also different for the two charges.

The important comparison that can be made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. It can be seen from TABLE 20 that the heavily cased charges (2.4-pound cased) in tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7-pound cased, test 13) by a factor of 1.7 in the Type B panel. Additionally, the heavily cased charge produced stresses 4 times higher than the equivalent bare charge for Type B. In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance. CG2 in the SIFCON shows an increase of 4.5 times over the equivalent bare charge. It is important to note that these comparisons are being made for charges of *equivalent impulse*, not simply equivalent explosive weight. The fragment impulse is being accounted for in the bare charge equivalent weight.

TABLE 20. PIEZORESISTIVE SHOCK PRESSURE CARBON GAGE (CG) DATA.

Gage Location (App. C Location)	Pressures (psi)					
	Test 13 (B/2.7C)	Test 14 (B/2.4E)	Test 15 (B2.4C) (2nd Peak)	Test 16 (B/2.8E)	Test 19 (C/2.4C) (2nd Peak)	Test 20 (C/2.8E)
CG1: (11)	34467	7250	58000	14000	>100000	>100000
CG2: (9)	33495	4133	43500	8200	68000 (22000)	14500
CG3: (12)	32973	4688	[illegible] (6[illegible])	4592	18000	9650
CG4: (10)	35054	[illegible]432	15000 (7500)	No Data	7000 (3000)	3000

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge
(B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge
(B/2.4C) = Wall Type B/2.4-pound Cased Charge
(B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge
(C/2.4C) = Wall Type C/2.4-pound Cased Charge
(C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

B. RECOMMENDATIONS

Future work in the definition of the synergism in blast and fragment loadings should include a second phase of laboratory testing and some additional analysis as well as some effort to integrate the information derived from research and testing into design guidance for protective construction. These phases should be conducted as follows:

PHASE II:

(1) *Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen.* These tests would consist of gun launching fragments into instrumented construction targets. Measured stresses would indicate the extent to which the stress pulses from blast and impact coalesce. They would be assessed with blast by simultaneously detonating a sheet of high explosive to create a simulated concurrent blast pulse.

would be assessed with blast by simultaneously detonating a sheet of high explosive to create a simulated concurrent blast pulse.

(2) *Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations.* It will be essential to define the standoffs at which synergism or blast fragment interaction for stress wave generation can be expected. These tests can be conducted subscale with modelled bombs and targets.

PHASE III:

(1) *Analytic model development/refinement* to allow the prediction and definition of synergistic effects, response modes, and response magnitude

(2) *Selection of optimum materials and structural configurations* for combined blast and fragment loading scenarios

REFERENCES

1. Fundamentals of Protective Design For Conventional Weapons - TM 5-855-1, prepared by the U.S. Army Waterways Experiment Station, Vicksburg, Mississippi, 1982.

2. Crawford, R.E., et al., Protection from Nonnuclear Weapons, Technical Report No. AFWL-TR-70-127, Air Force Weapons Laboratory, Kirtland AFB, NM, 1971.

3. Whitney, M.G., et al., Structures to Resist the Effects of Accidental Explosions Volume II, Blast, Fragment, and Shock Loads, Special Publication ARLCD-SP-84001, U.S. Armament Research, Development and Engineering Center, Dover, NJ, 1986.

4. Baker, W.E., et al., A Manual for the Prediction of Blast and Fragment Loadings on Structures, DOE/TIC-11268, U.S. Department of Energy, Pantex Plant, Amarillo, TX, 1980.

5. Carre, G.L., Evaluation of Field Fortifications, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1968.3) "Effects of Impact and Explosion", Summary Technical Report of The National Defense Research Committee, Volume 1, 1946.

6. Marchand, K.A., et al., "Impulsive Loading of Special Doors: Flyer Plate Impact of Heavily Reinforced Concrete Blast Doors-Test Program Results," Southwest Research Institute, 1986.

7. Coltharp, D.R., et al., "Blast Response Tests of Reinforced Concrete Box Structures-Methods for Reducing Spall," Proceedings of the Second Symposium on the Interaction of Nonnuclear Munitions with Structures, 1985.

8. Marchand, K.A. and Vargas, L.M., "A Technical Literature Review in Support of Research Concerning the Synergism in Blast and Fragment Loadings," SwRI Project 06-2821, Contract No. F08635-89-C-0195, AFESC, Tyndall AFB, FL, August 1989.

9. Dynasen Inc. Catalog, "Shock Pressure Sensors and Connector/Cable Assemblies, Dynasen Inc., Goleta, California, Mullin, S.A., et al.

10. PCB Piezotronics Mini Catalog 47b, PCB Piezotronics, Depew, New York.

11. "Kulite Solid State Transducer Technology," Transducer Catalog, Kulite Semiconductor Products, Inc., Ridgefield, New Jersey.

REFERENCES
(continued)

12. "Effects of Impact and Explosion," Summary Technical Report of the National Defense Research Committee, Volume 1, 1946.

13. Mullin, S.A., "Explosive Shock Testing: Close Proximity Blast Measurements," Southwest Research Institute Project 06-2403-002, April 1989.

14. Mullin, S.A. and Esparza, E.D., "Explosive Shock Testing: Materials Evaluation," Southwest Research Institute Project 06-2403-001, January 1989.

15. Marchand, K.A. et al., "Development of an Alternate Munition Storage Barrier System, Phase II Report-Tests of the Barrier Concepts," SwRI Project 06-8986, Contract No. DACA88-86-D-0017, US Army Construction Engineering Research Laboratory, Champaign Illinois, July 1989.

16. "Project THOR Report No. 25--A Comparison of Various Materials in Their Resistance to Perforation by Steel Fragments; Empirical Relationships," Johns Hopkins University, Baltimore, Maryland, 1956.

17. Krauthammer, T. and Shahrian, S., "A Computational Method for Evaluating Modular Prefabricated Structural Element for Rapid Construction of Facilities," ESL-TR-87-60, Air Force Engineering and Services Laboratory, July, 1988.

18. Krauthammer, T., "Structural Analysis for Severe Dynamic Environments," March 1989.

19. Baylot, J.T., Kiger, S.A., Marchand, K.A. and Painter, J.T., "Response of Buried Structures to Earth-Penetrating Conventional Weapons," ESL-TR-85-09," Air Force Engineering and Services Laboratory, November 1985.

20. Ross, C.A., et al., "Concrete Breaching Analysis," AFATL-TR-81-105, Air Force Armament Laboratory, December 1981.

21. McVay, M.K., "Spall Damage of Concrete Structures," SL-88-22, US Army Waterways Experiment Station, June 1988.

APPENDIX A

Test Data from Bare Charge Loads Tests

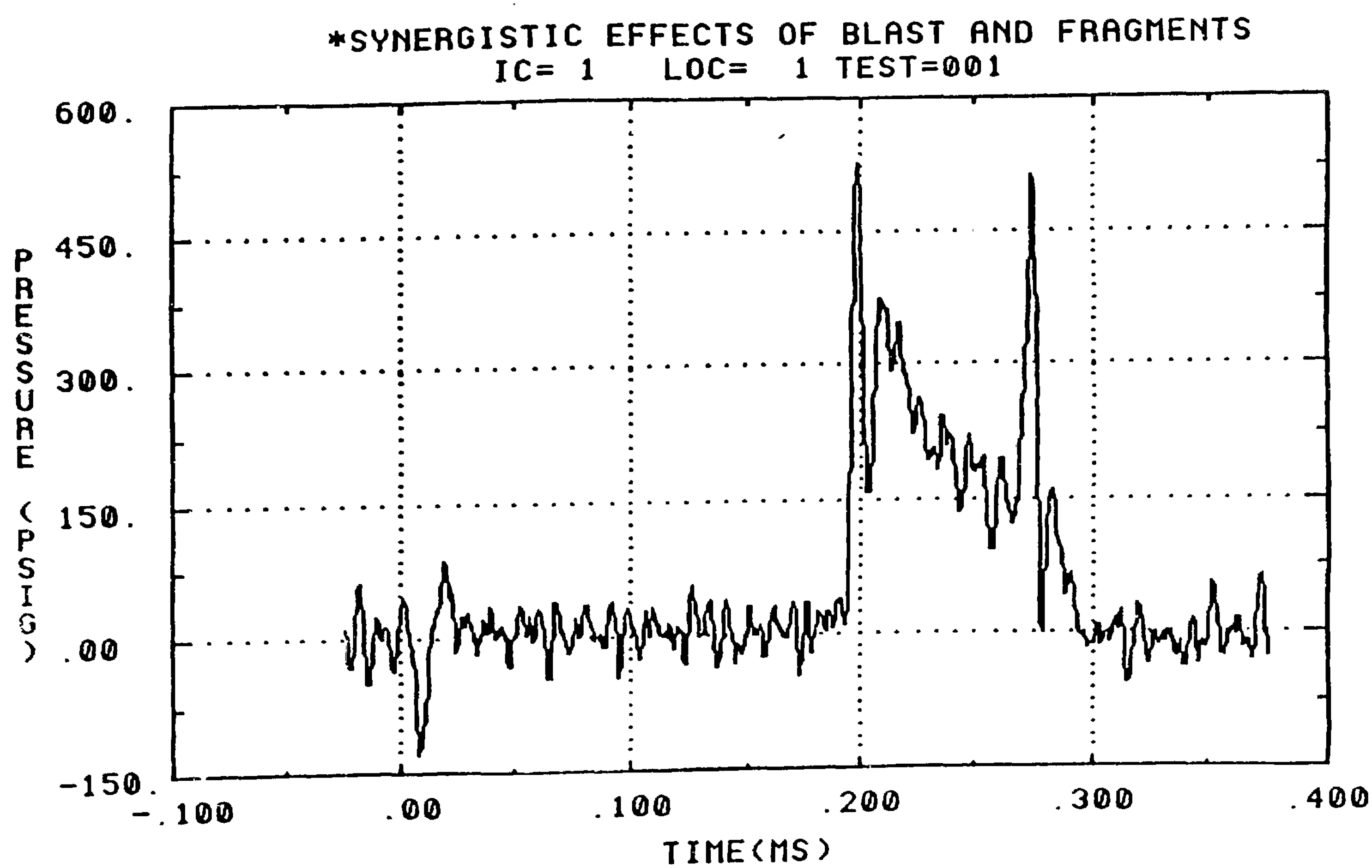


Figure A-1. Loads Test Data, Test 1, LOC 1.

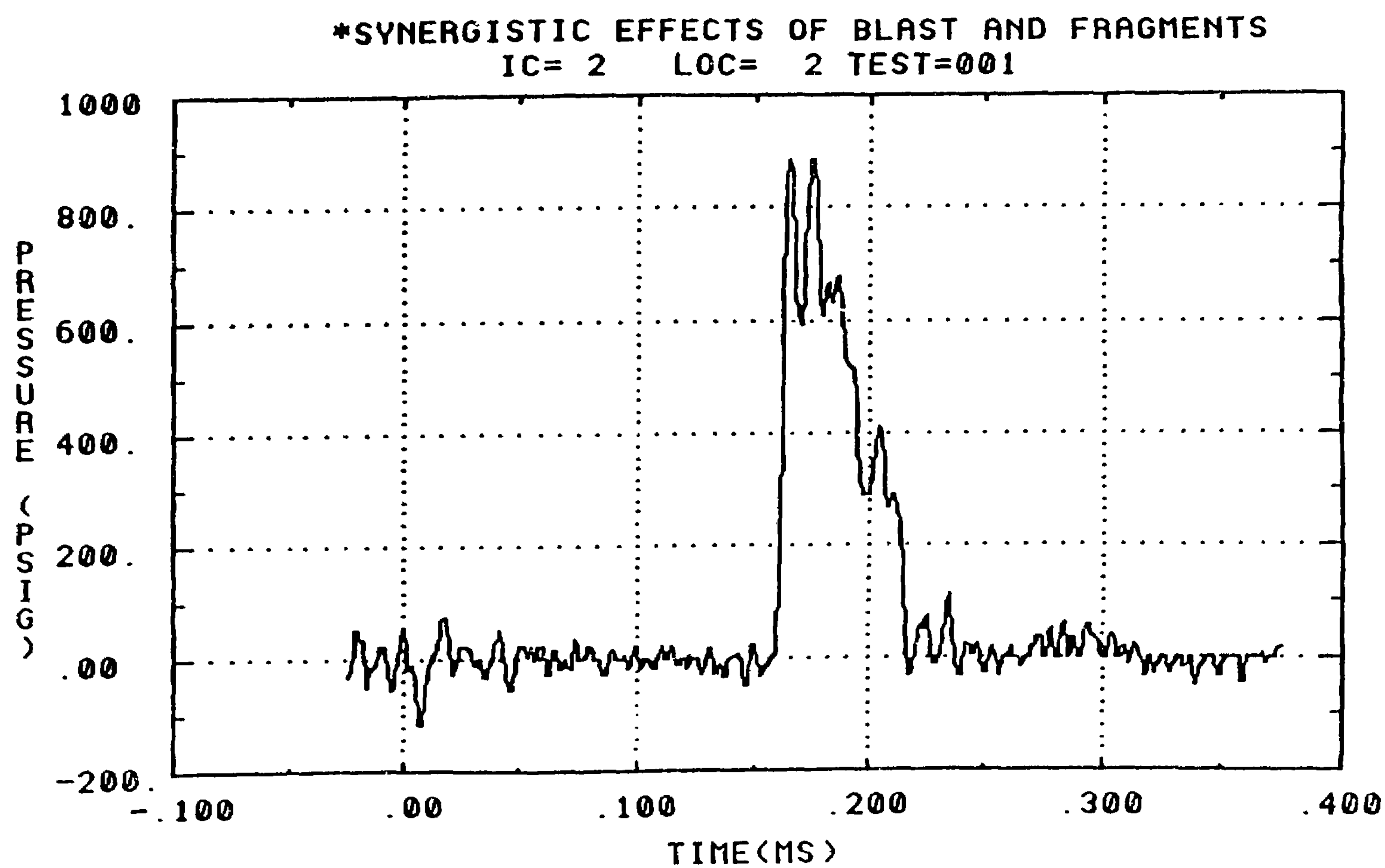


Figure A-2. Loads Test Data, Test 1, LOC 2.

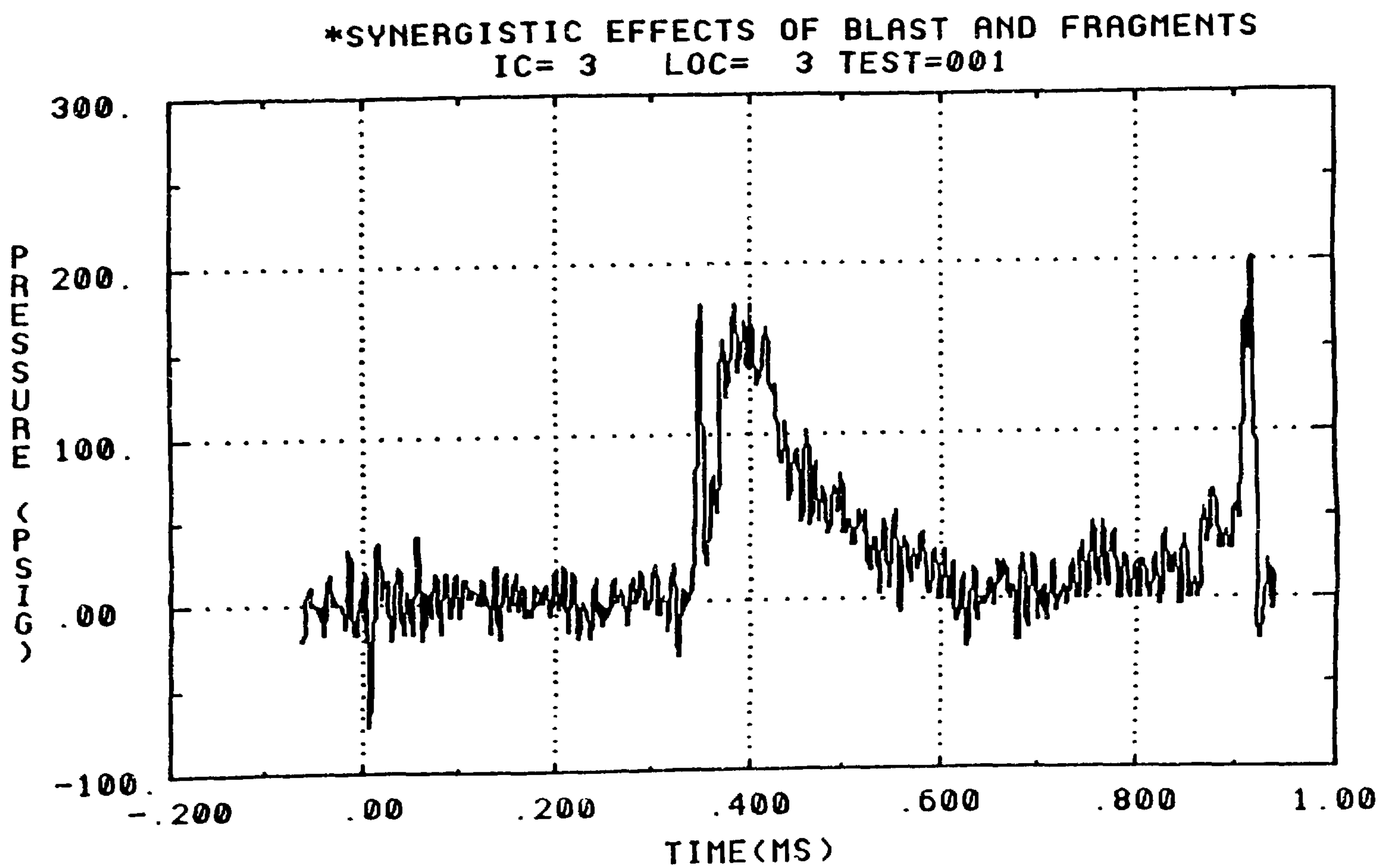


Figure A-3. Loads Test Data, Test 1, LOC 3.

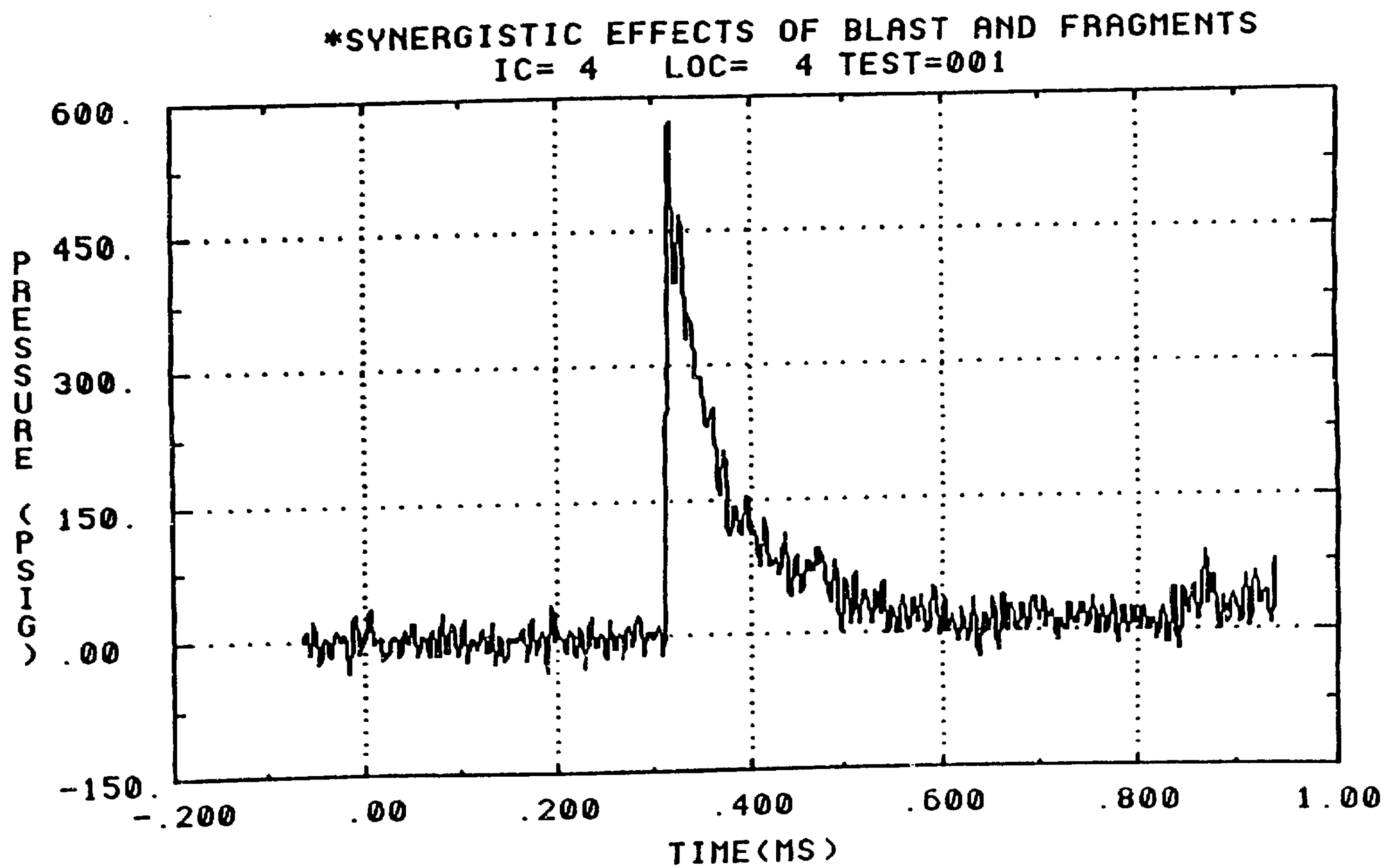


Figure A-4. Loads Test Data, Test 1, LOC 4.

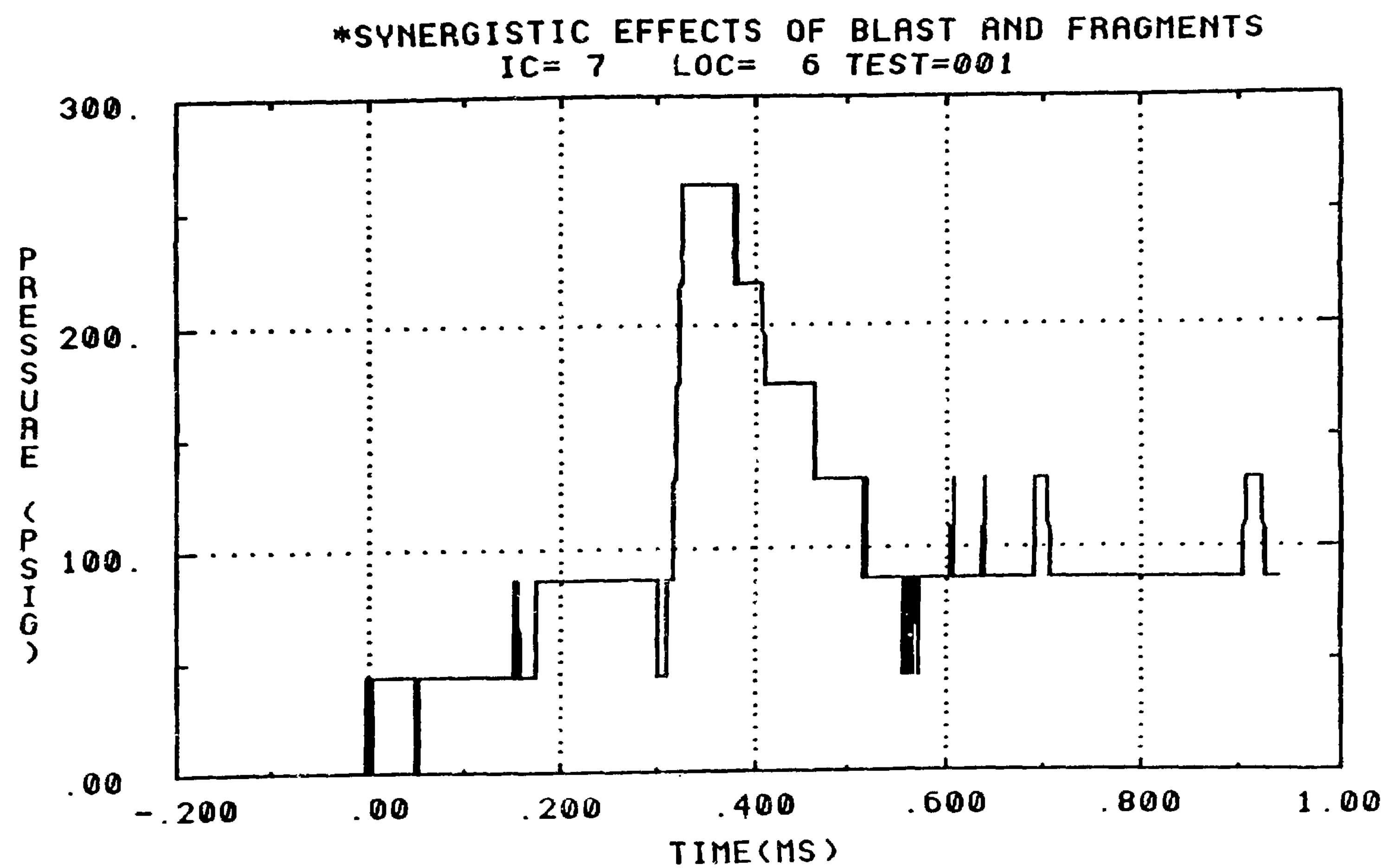


Figure A-5. Loads Test Data, Test 1, LOC 6.

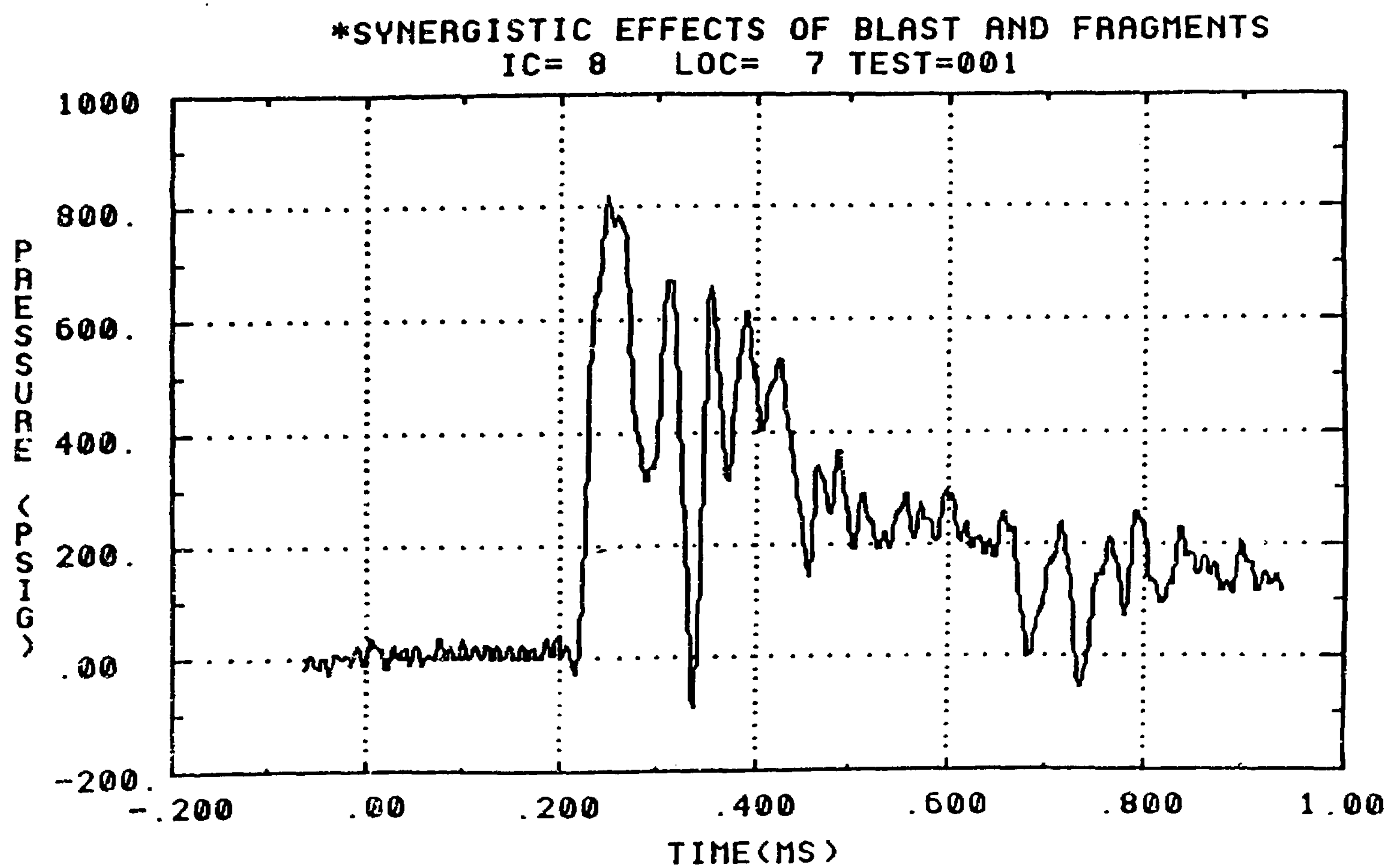


Figure A-6. Loads Test Data, Test 1, LOC 7.

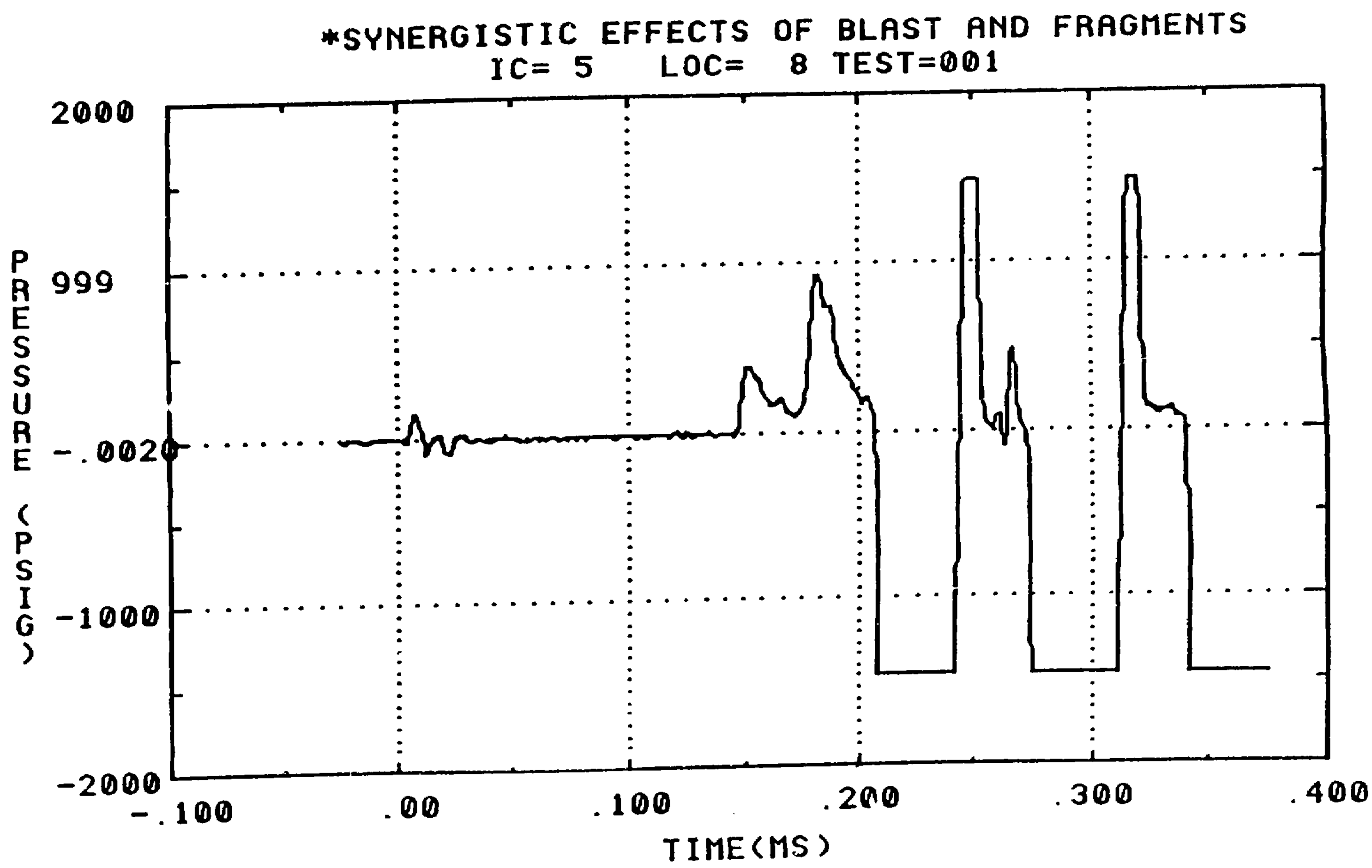


Figure A-7. Loads Test Data, Test 1, LOC 8.

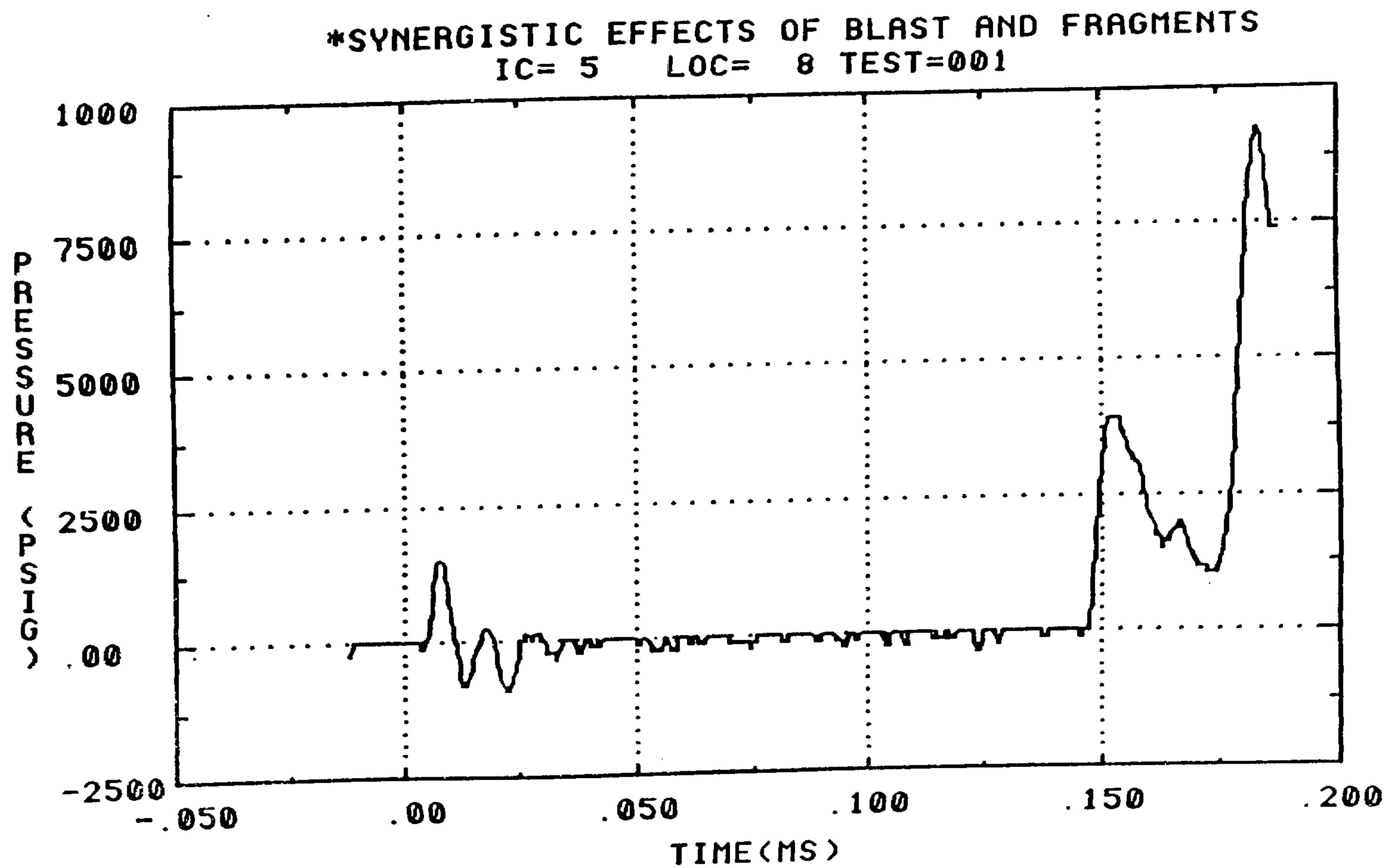


Figure A-8. Loads Test Data, Test 1, LOC 8.

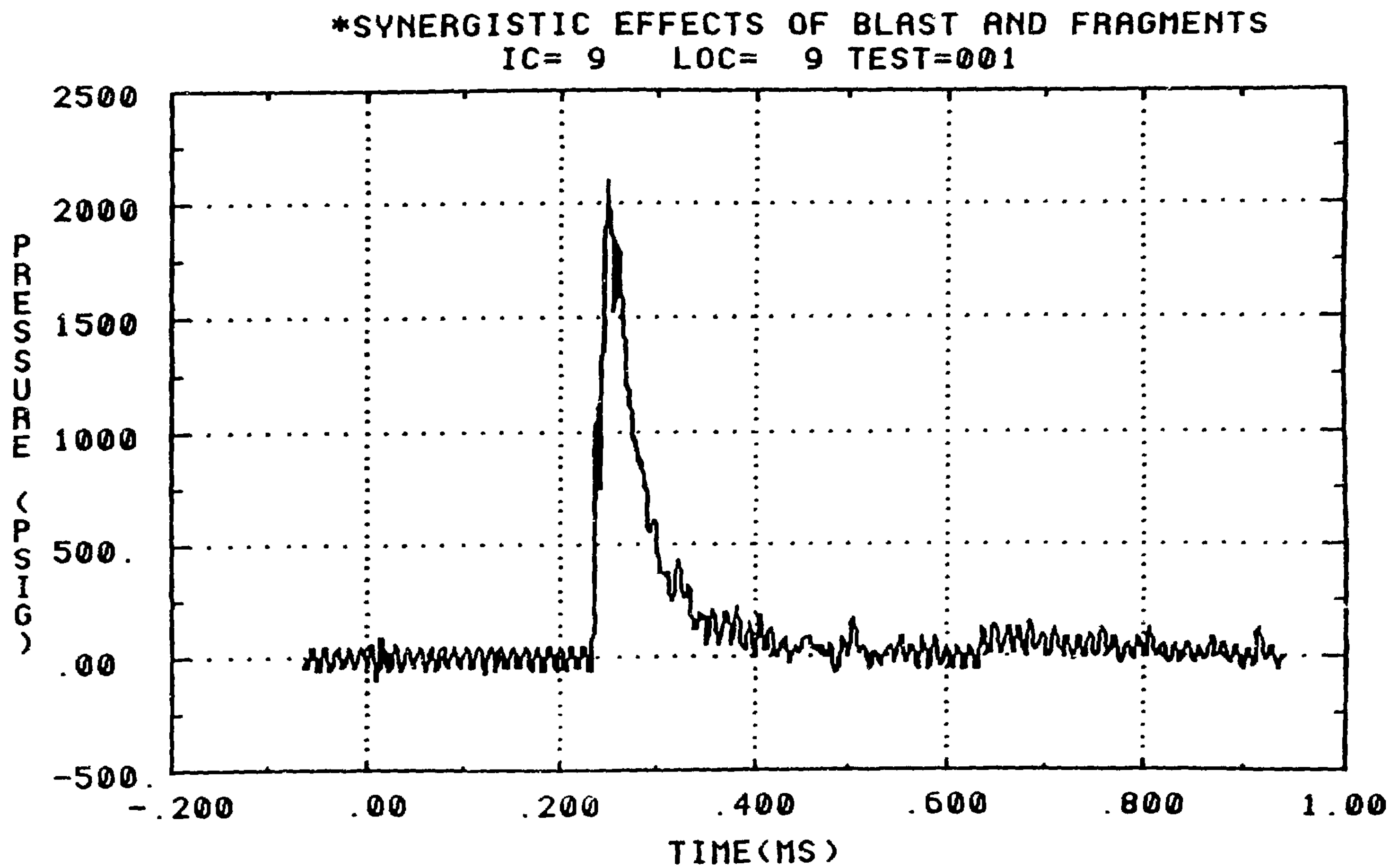


Figure A-9. Loads Test Data, Test 1, LOC 9.

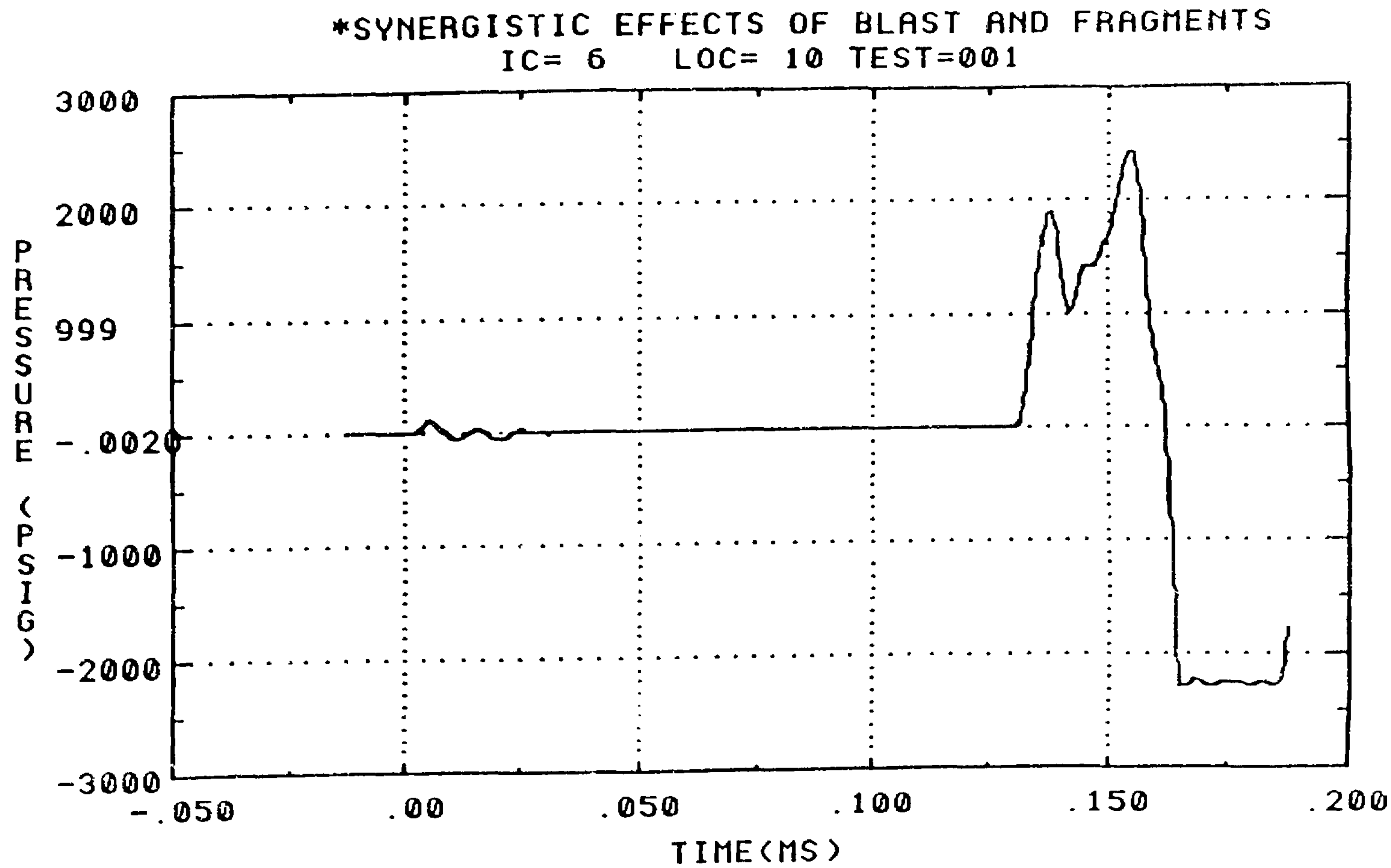


Figure A-10. Loads Test Data, Test 1, LOC 10.

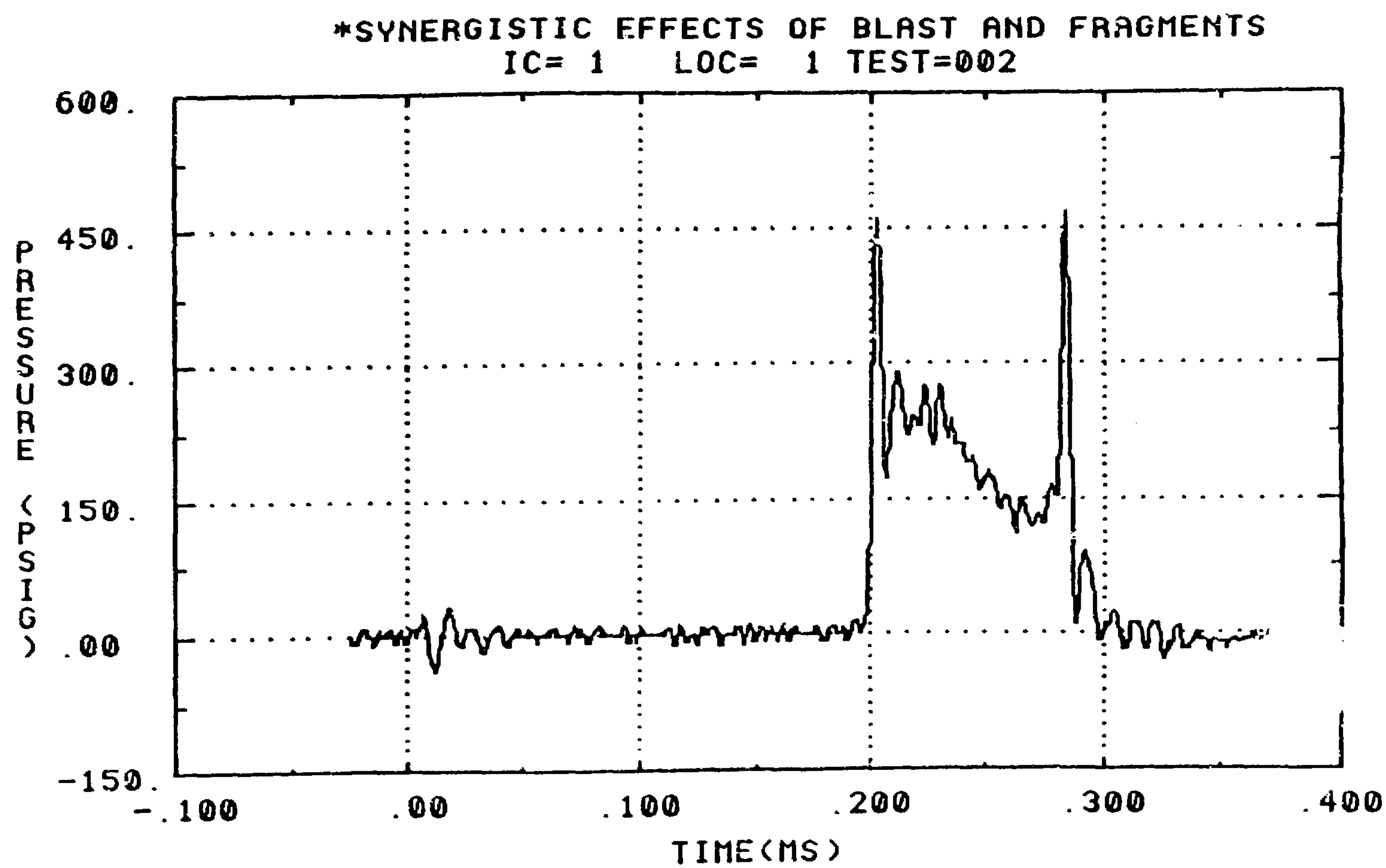


Figure A-11. Loads Test Data, Test 2, LOC 1

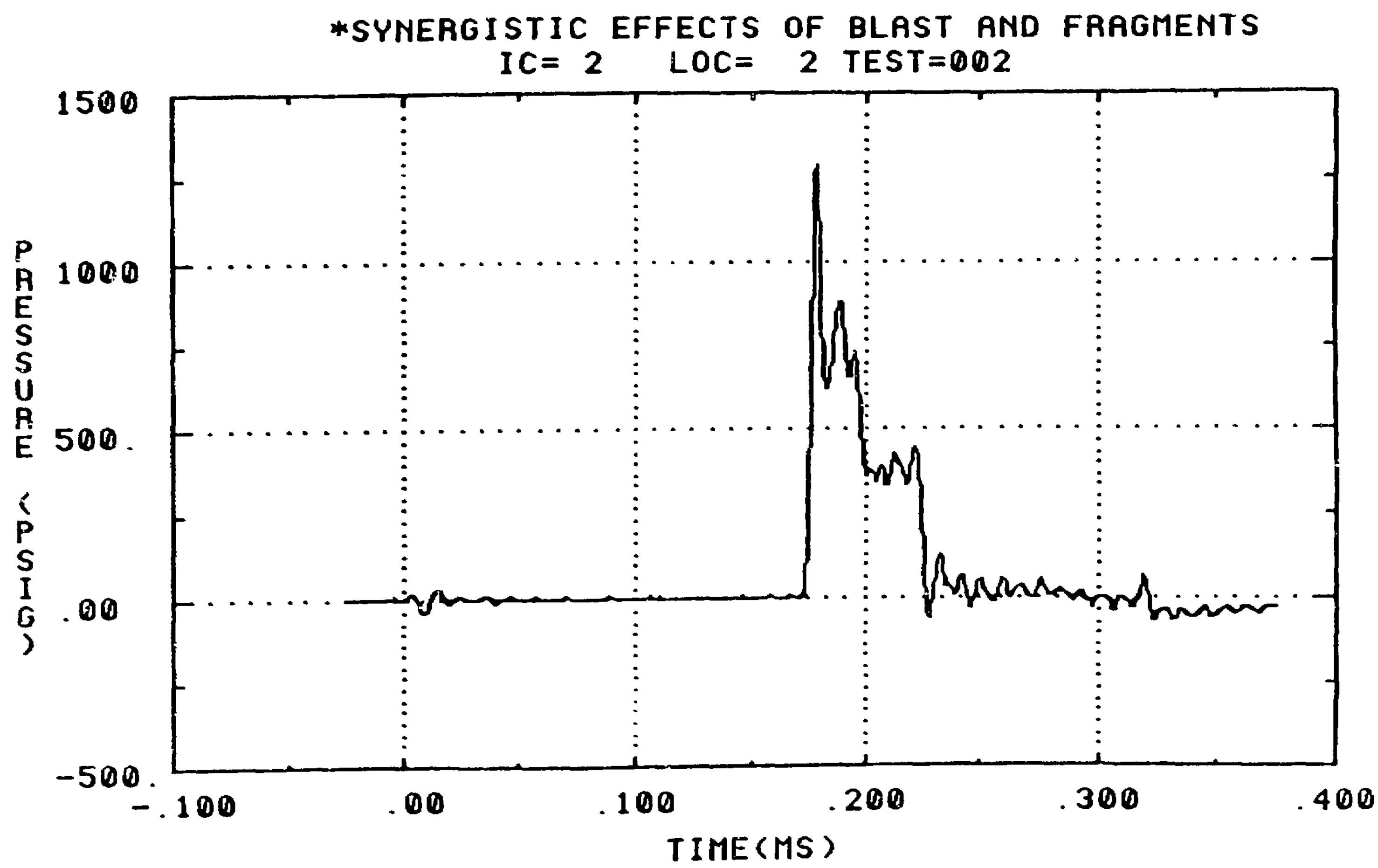


Figure A-12. Loads Test Data, Test 2, LOC 2

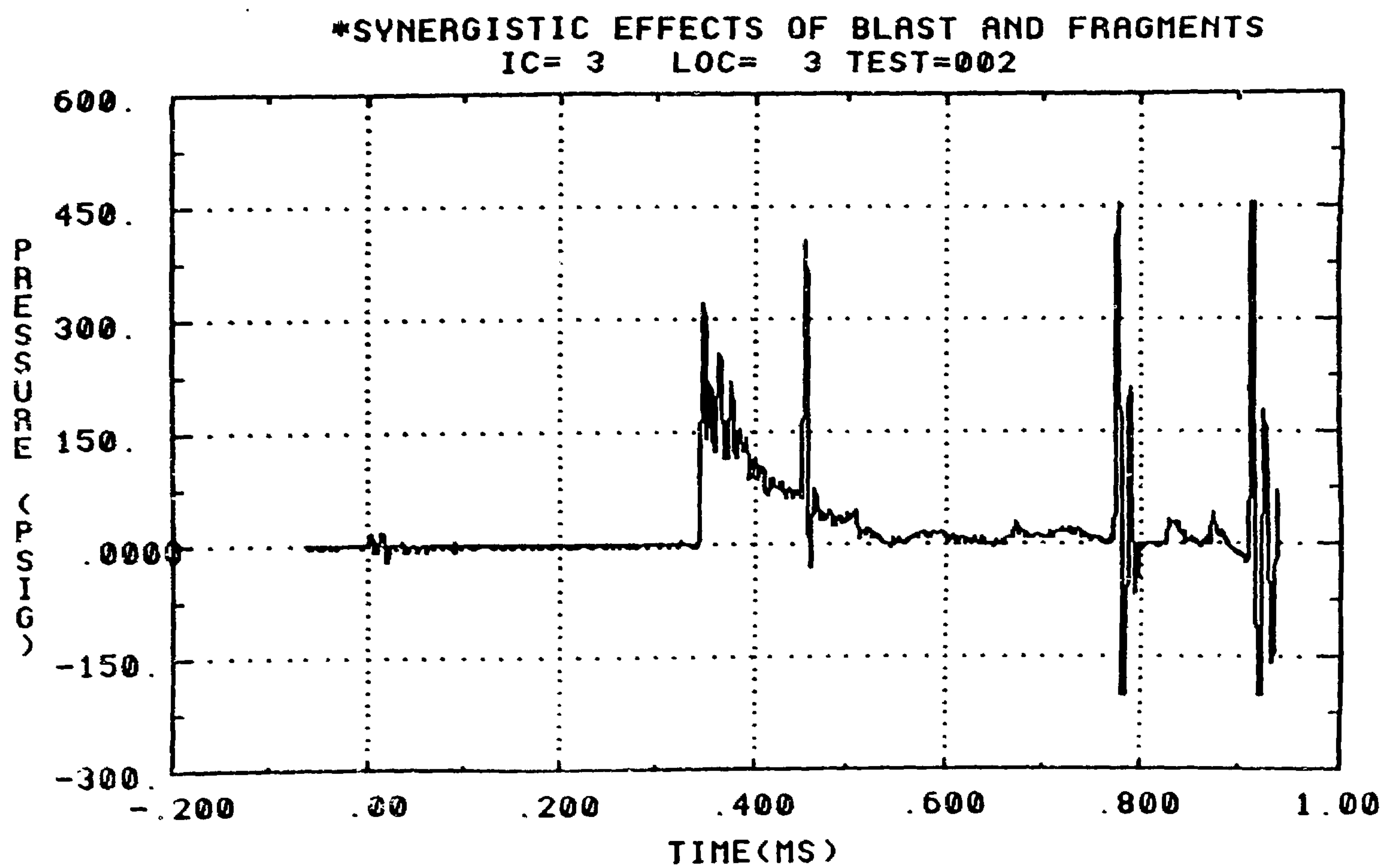


Figure A-13. Loads Test Data, Test 2, LOC 3

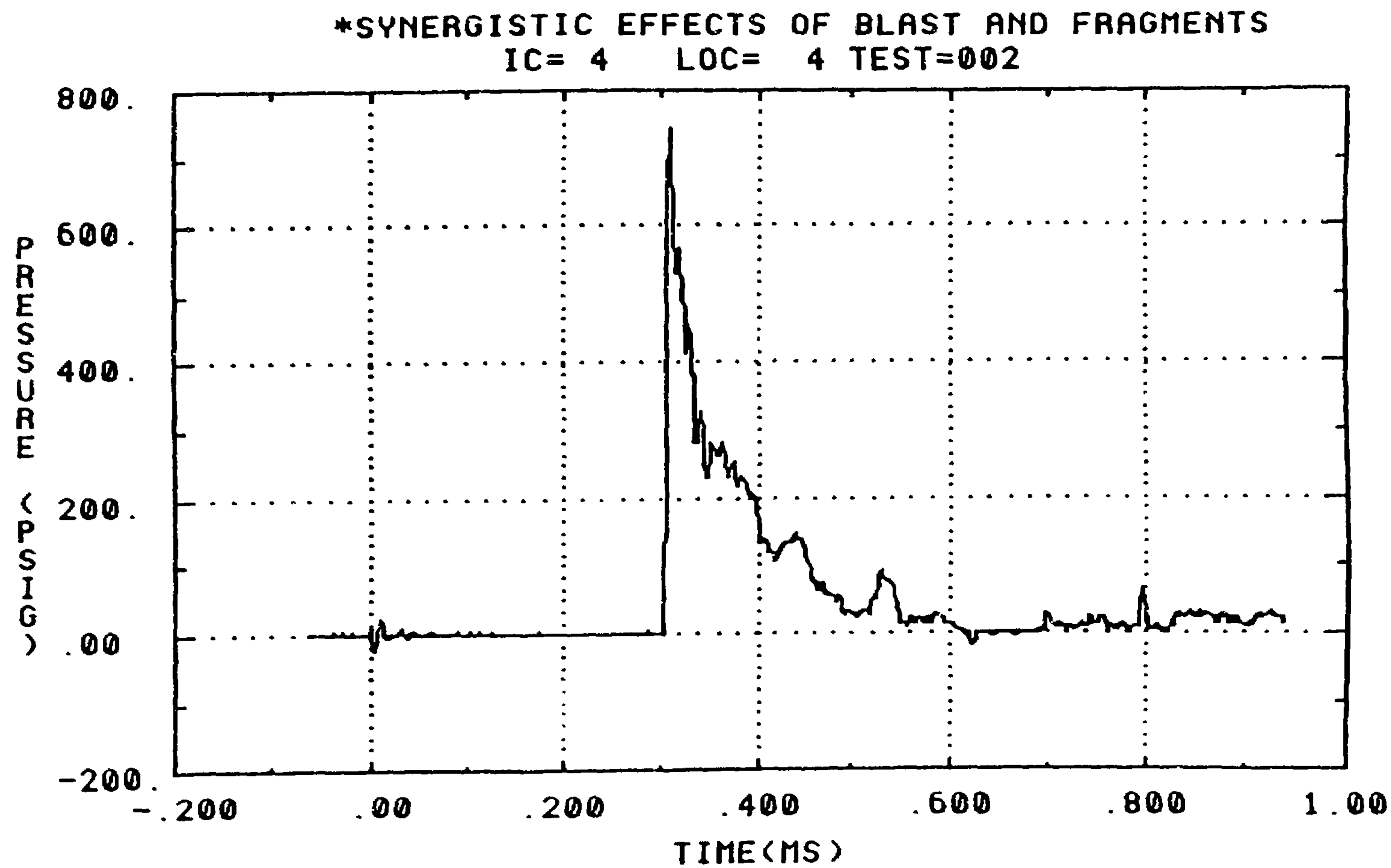


Figure A-14. Loads Test Data, Test 2, LOC 4

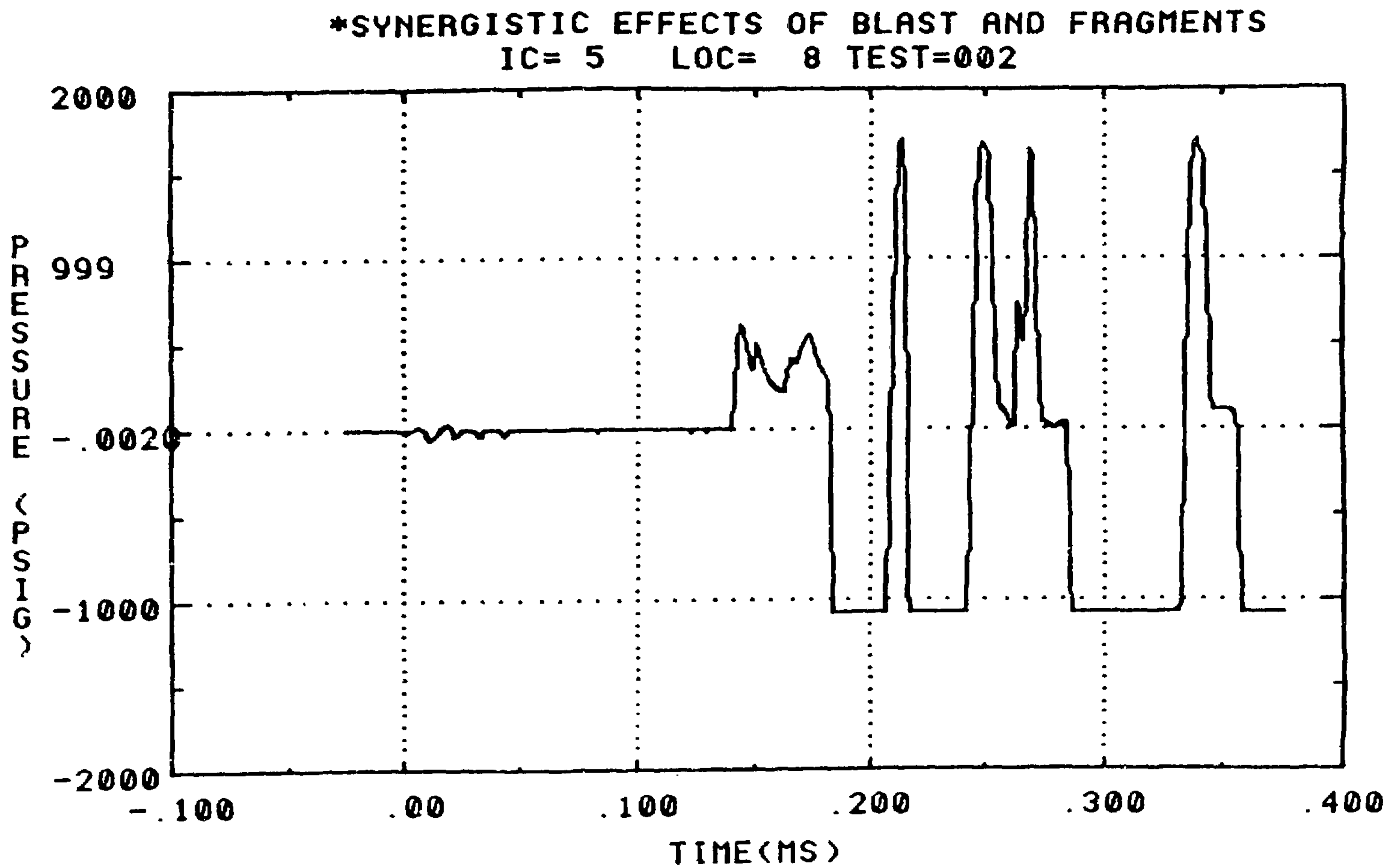


Figure A-15. Loads Test Data, Test 2, LOC 8

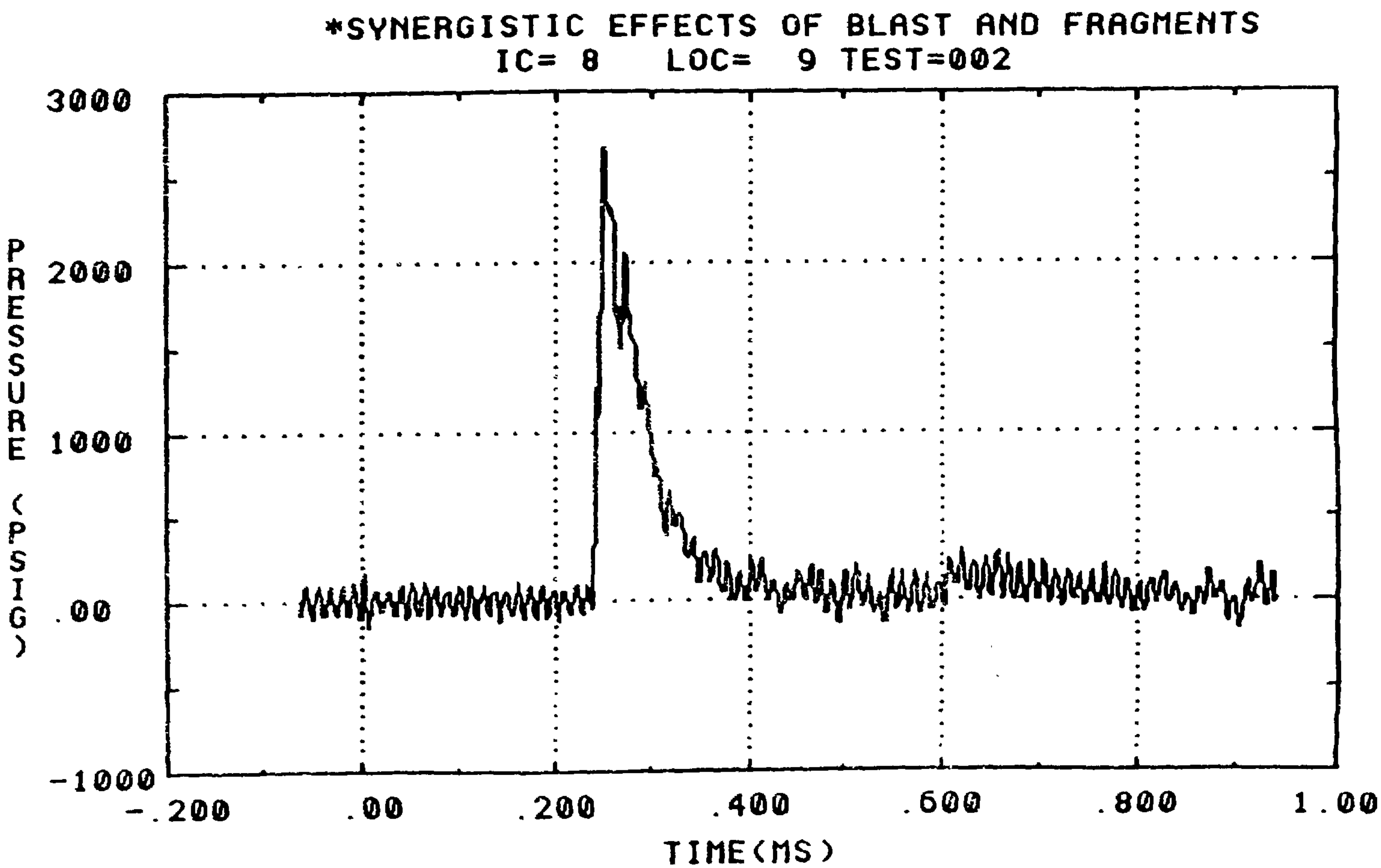


Figure A-16. Loads Test Data, Test 2, LOC 9

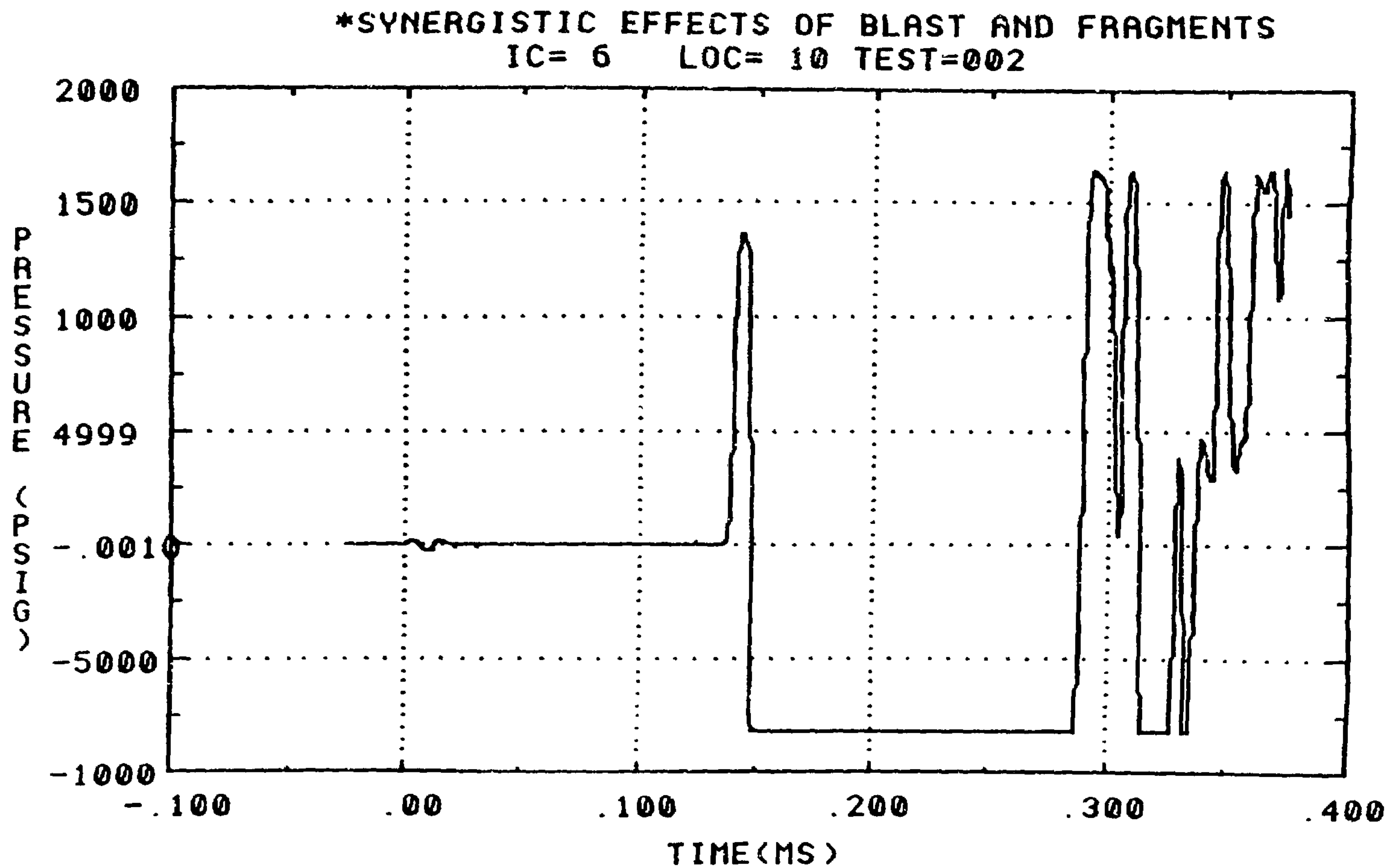


Figure A-17. Loads Test Data, Test 2, LOC 10

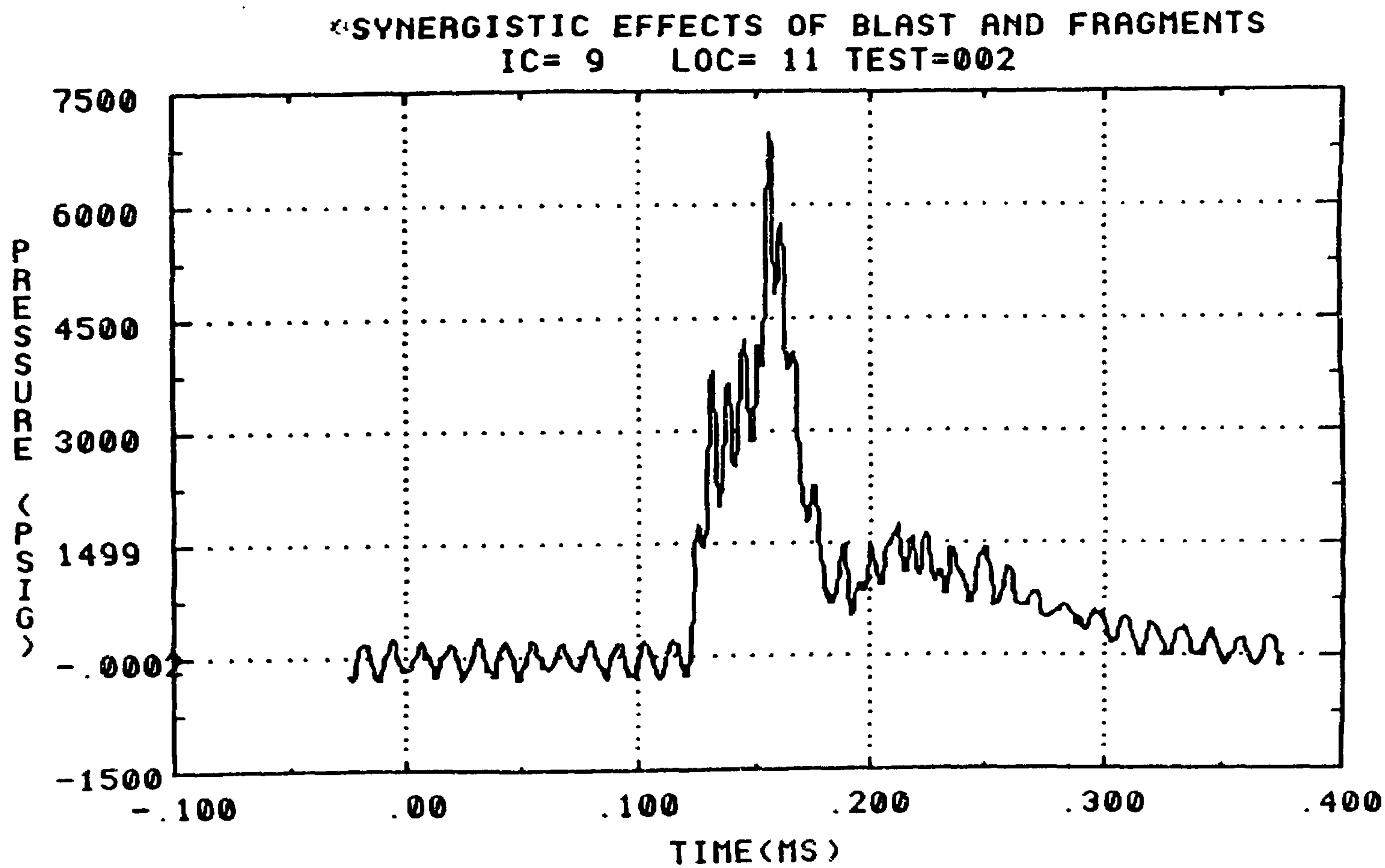


Figure A-18. Loads Test Data, Test 2, LOC 11

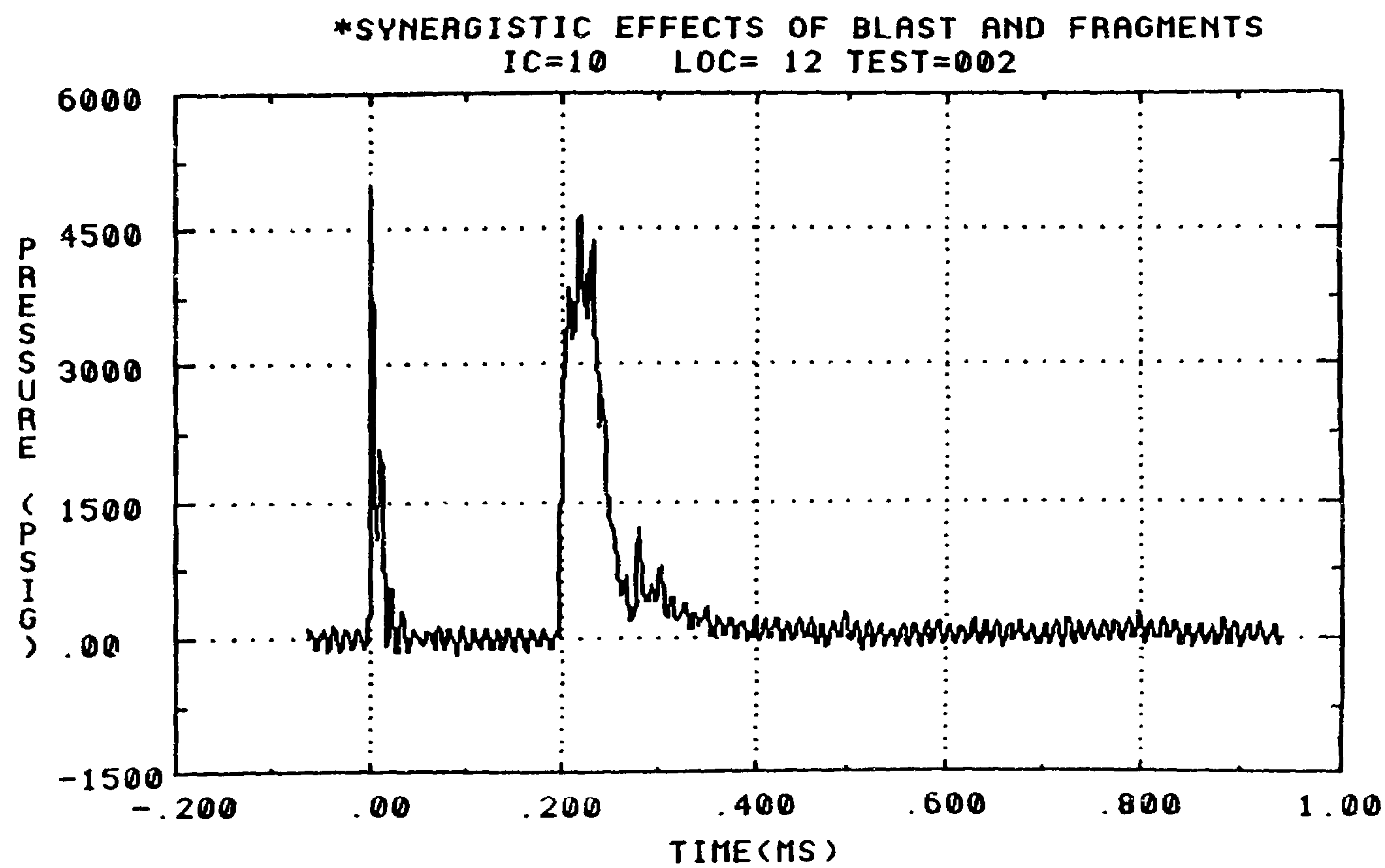


Figure A-19. Loads Test Data, Test 2, LOC 12

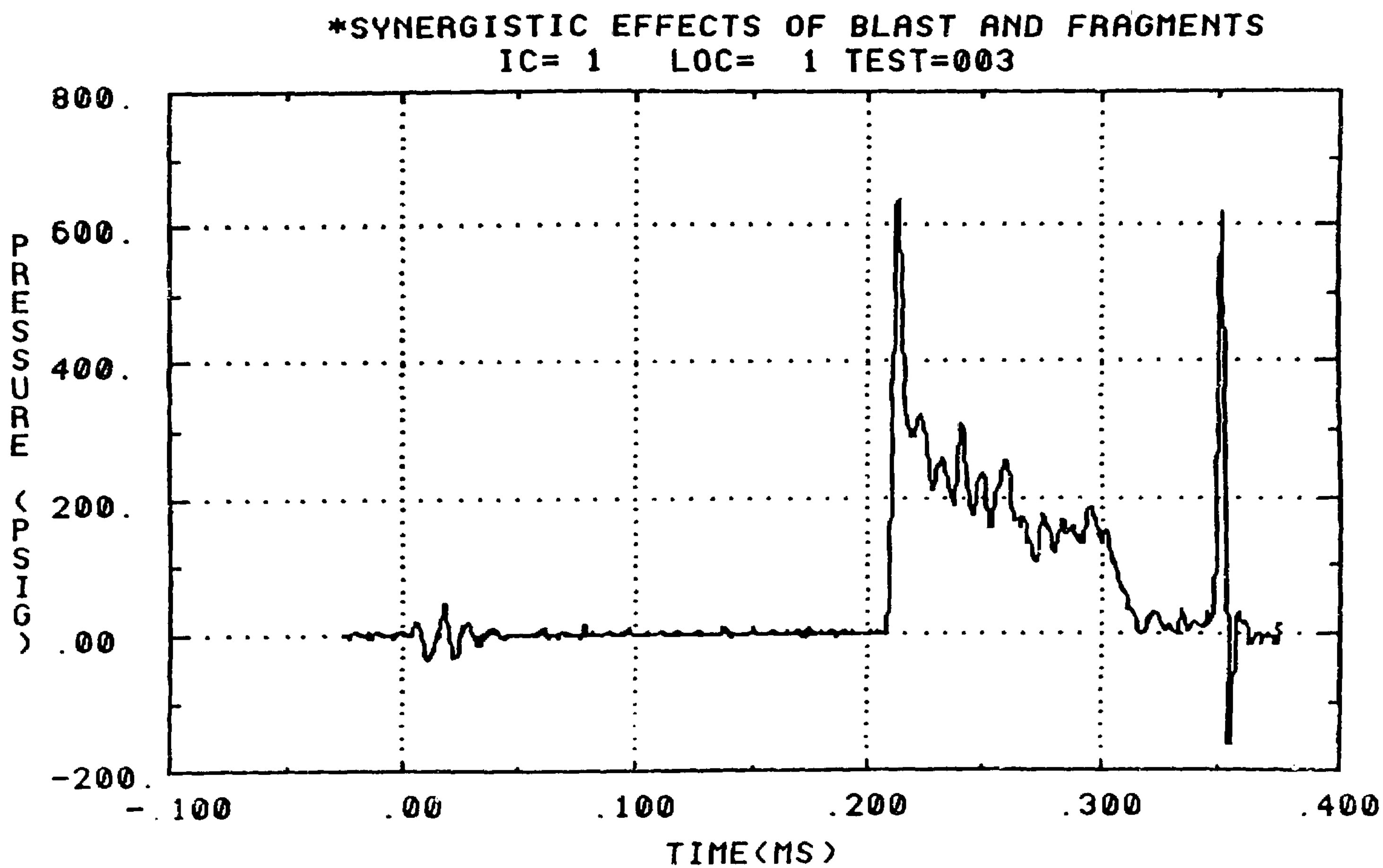


Figure A-20. Loads Test Data, Test 3, LOC 1

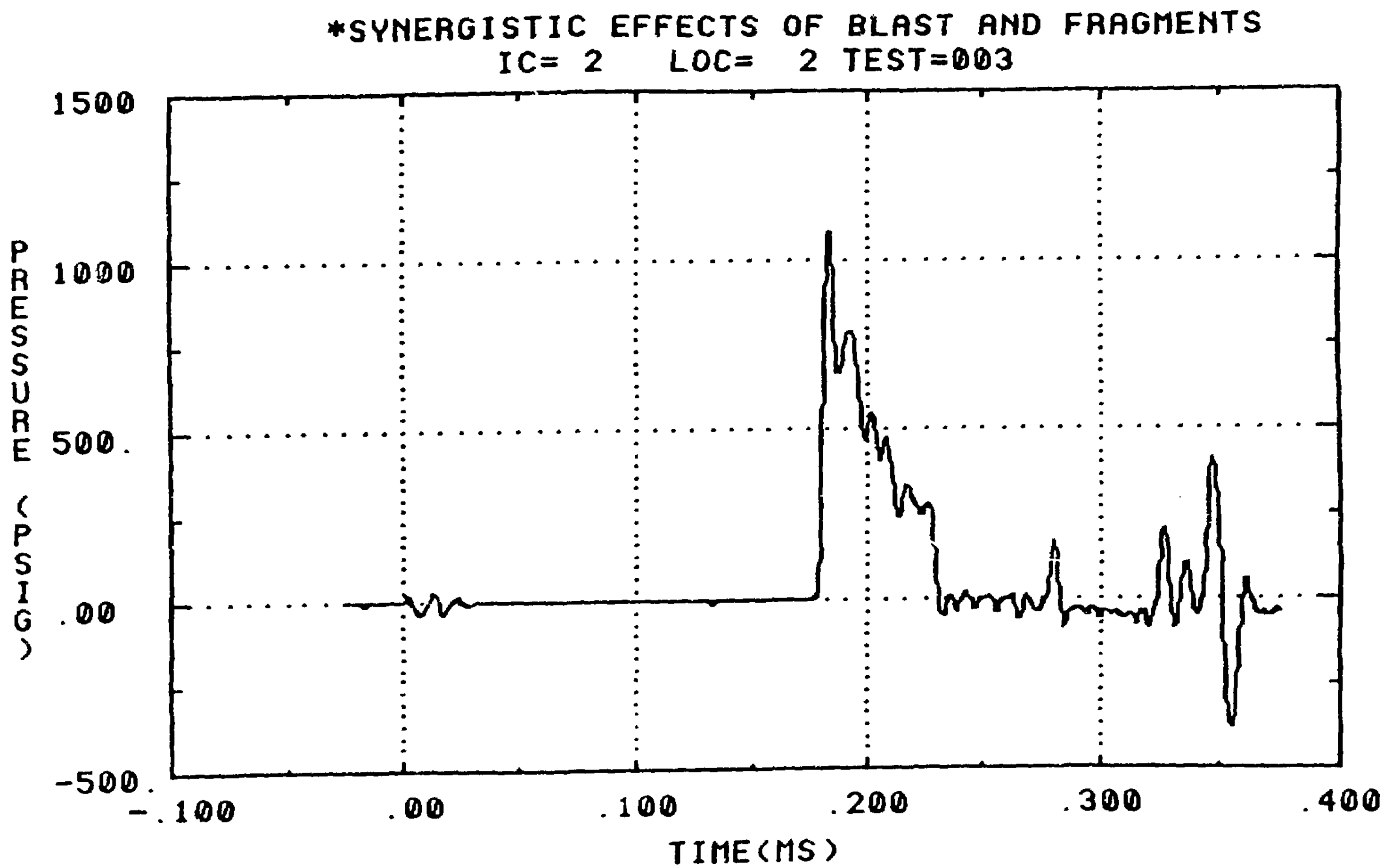


Figure A-21. Loads Test Data, Test 3, LOC 2

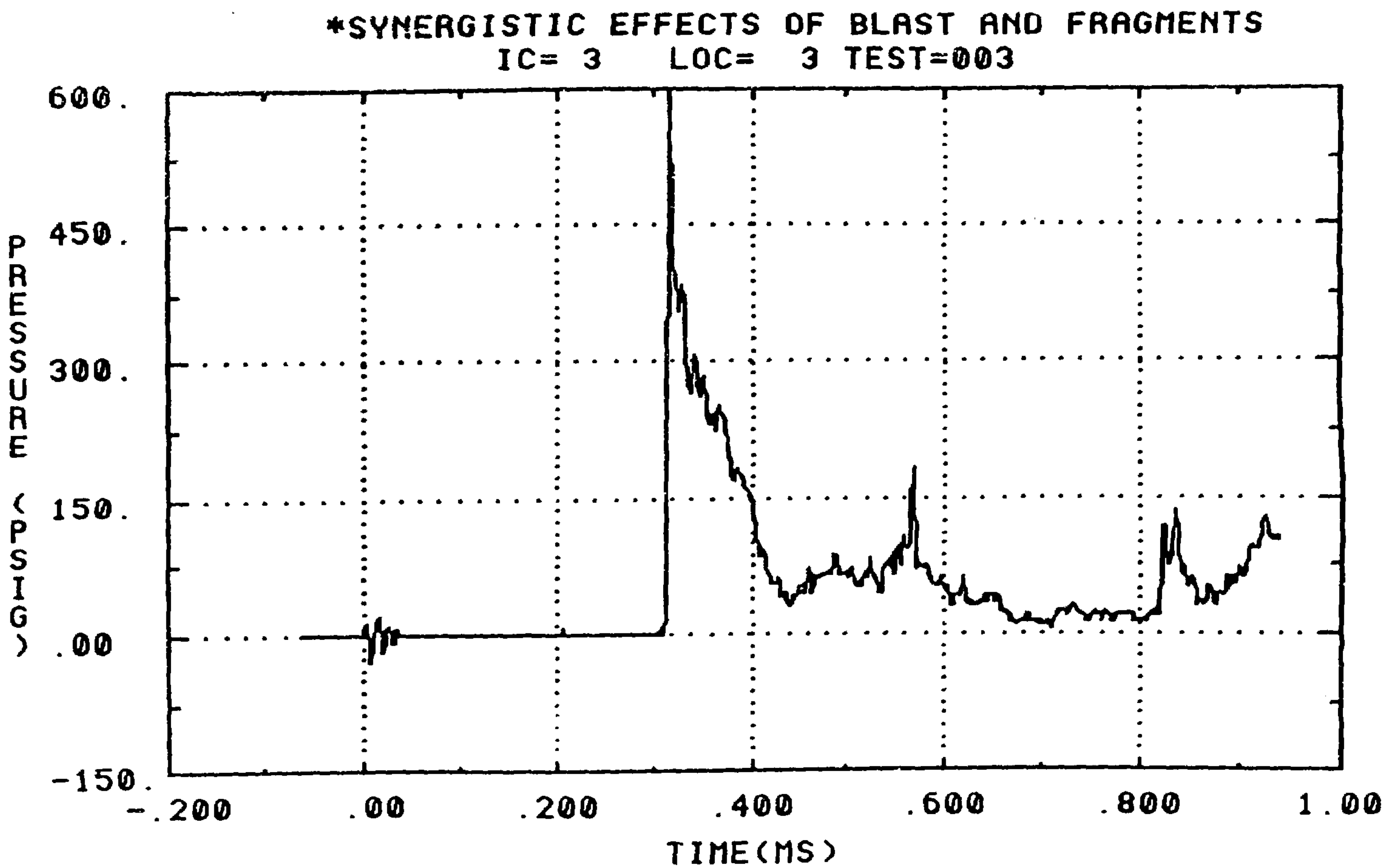


Figure A-22. Loads Test Data, Test 3, LOC 3

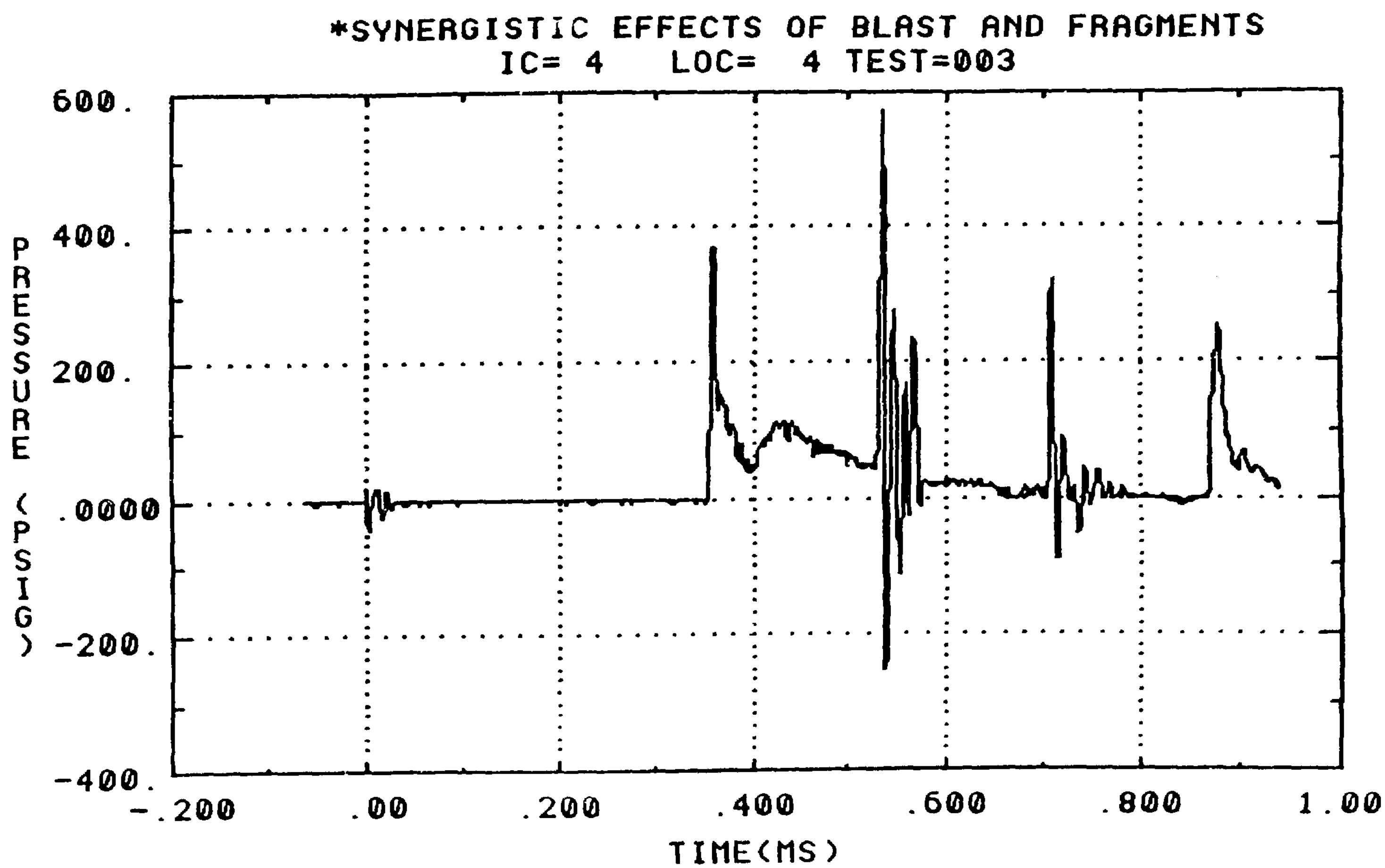


Figure A-23. Loads Test Data, Test 3, LOC 4

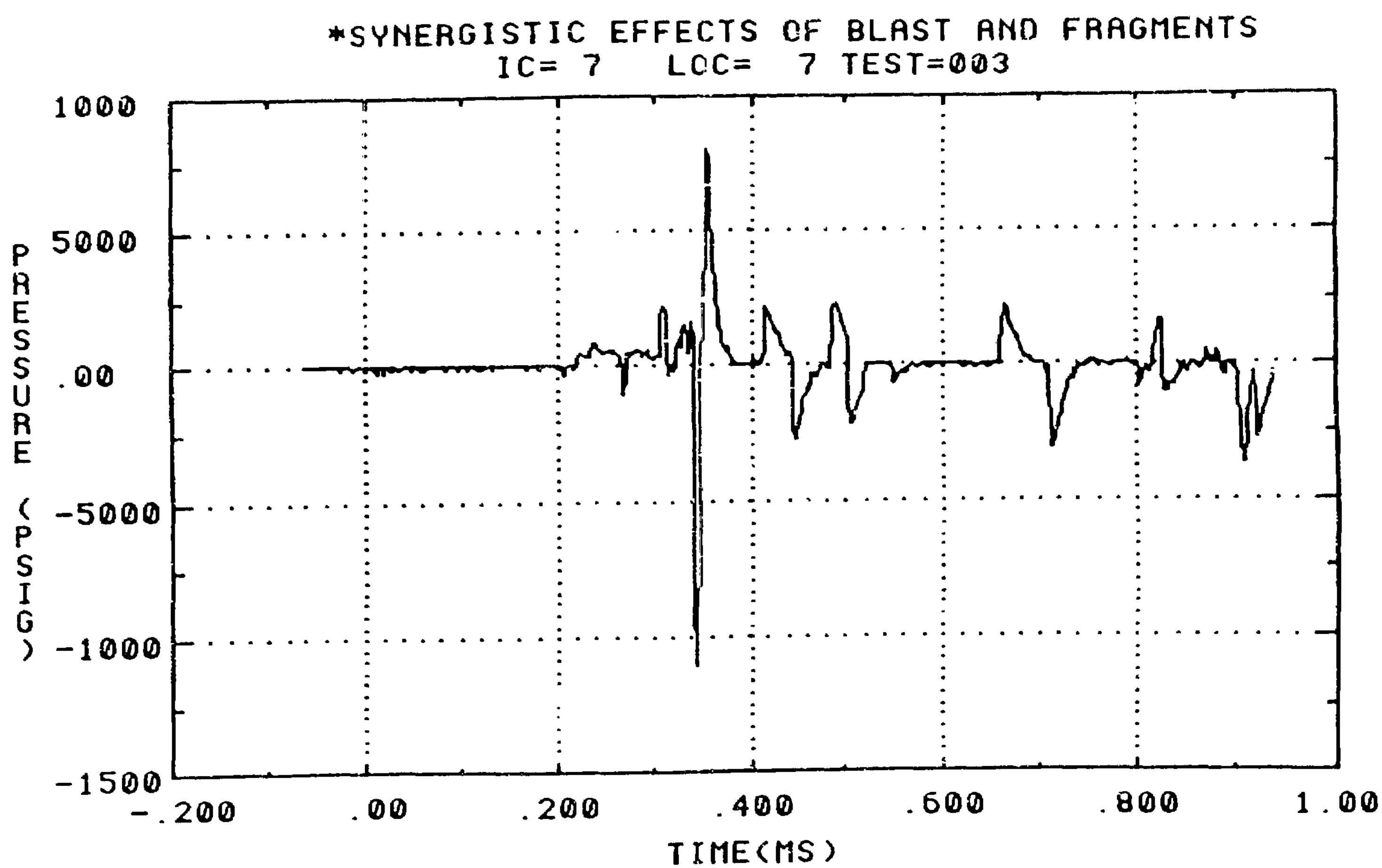


Figure A-24. Loads Test Data, Test 3, LOC 7

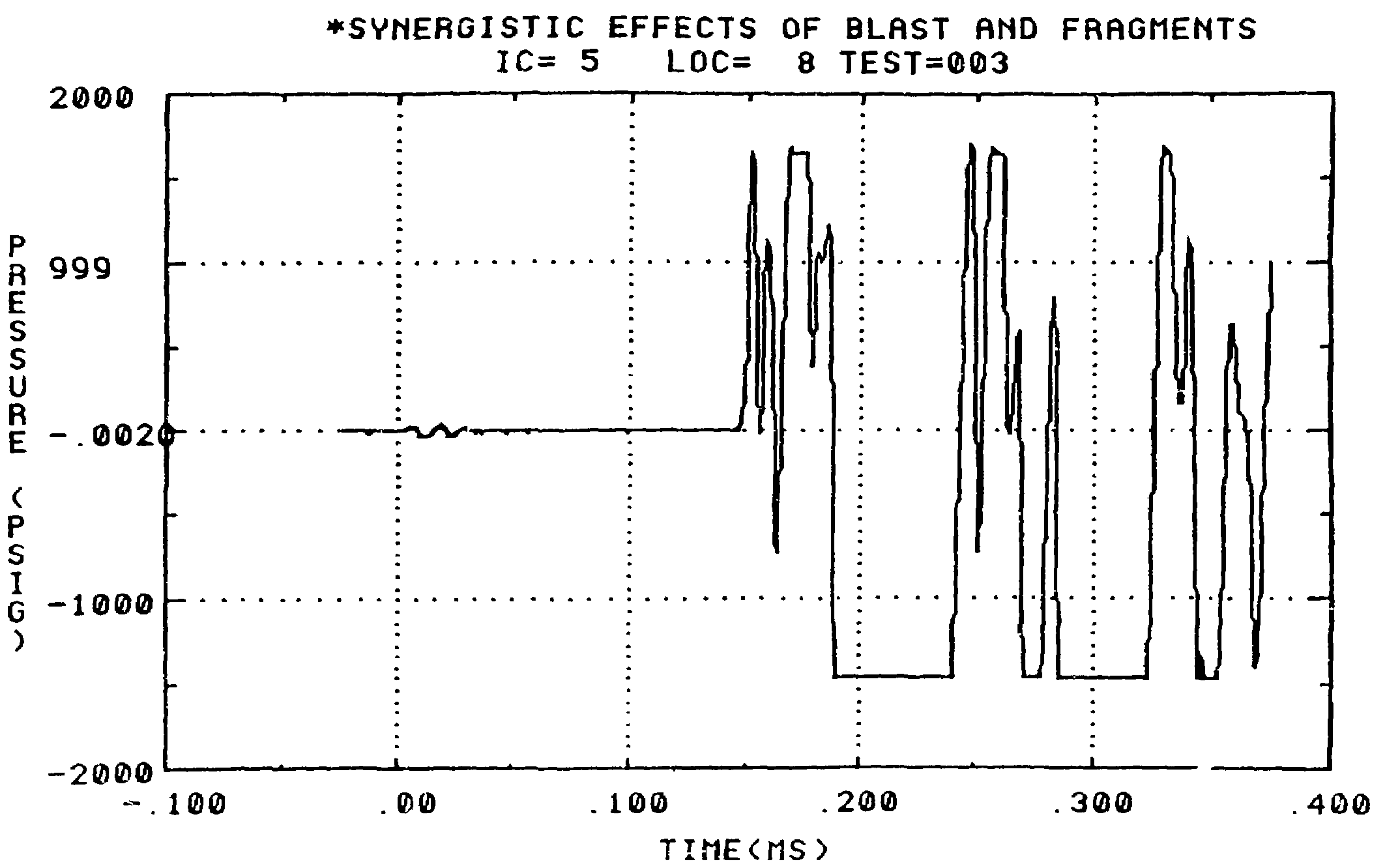


Figure A-25. Loads Test Data, Test 3, LOC 8

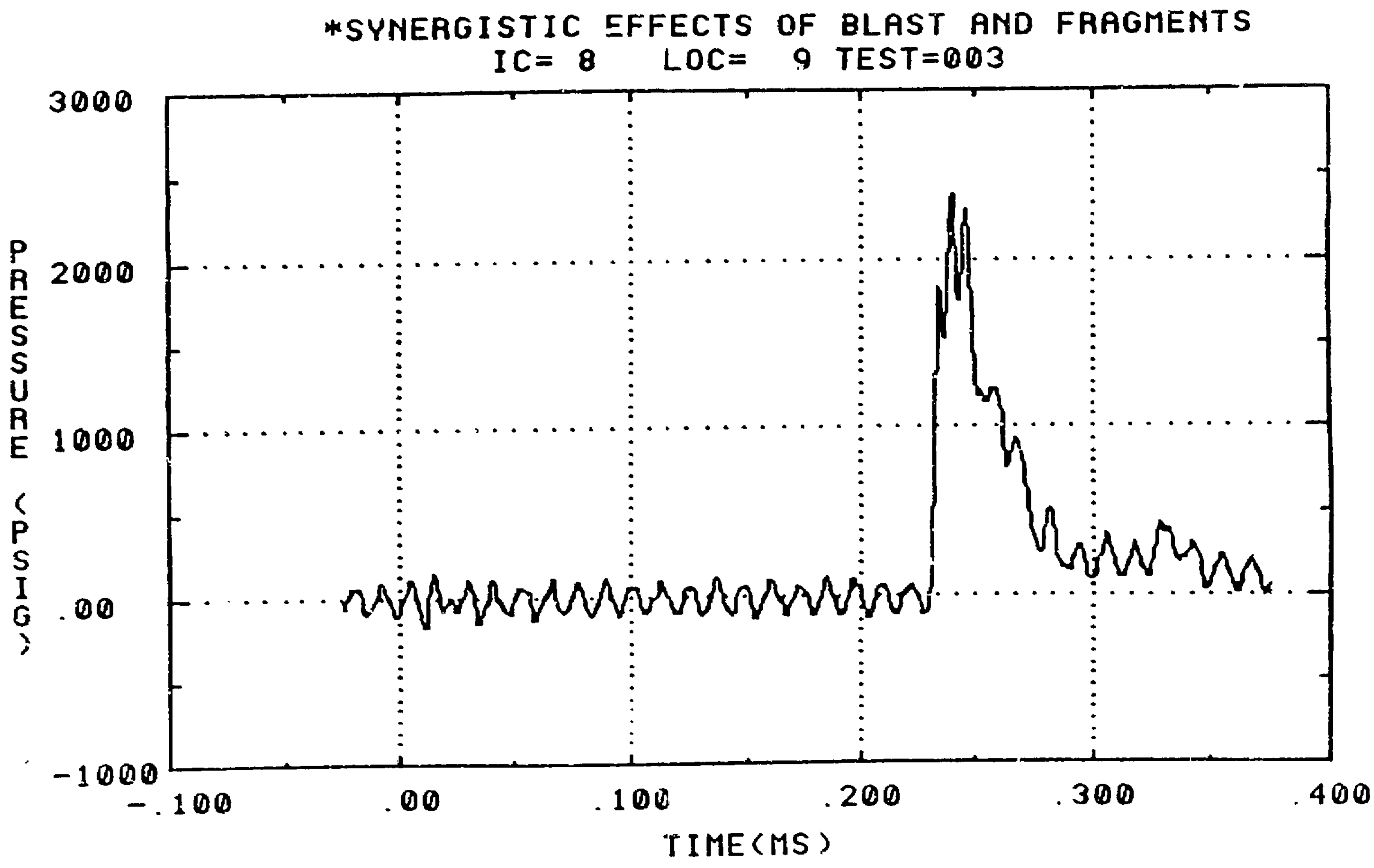


Figure A-26. Loads Test Data, Test 3, LOC 9

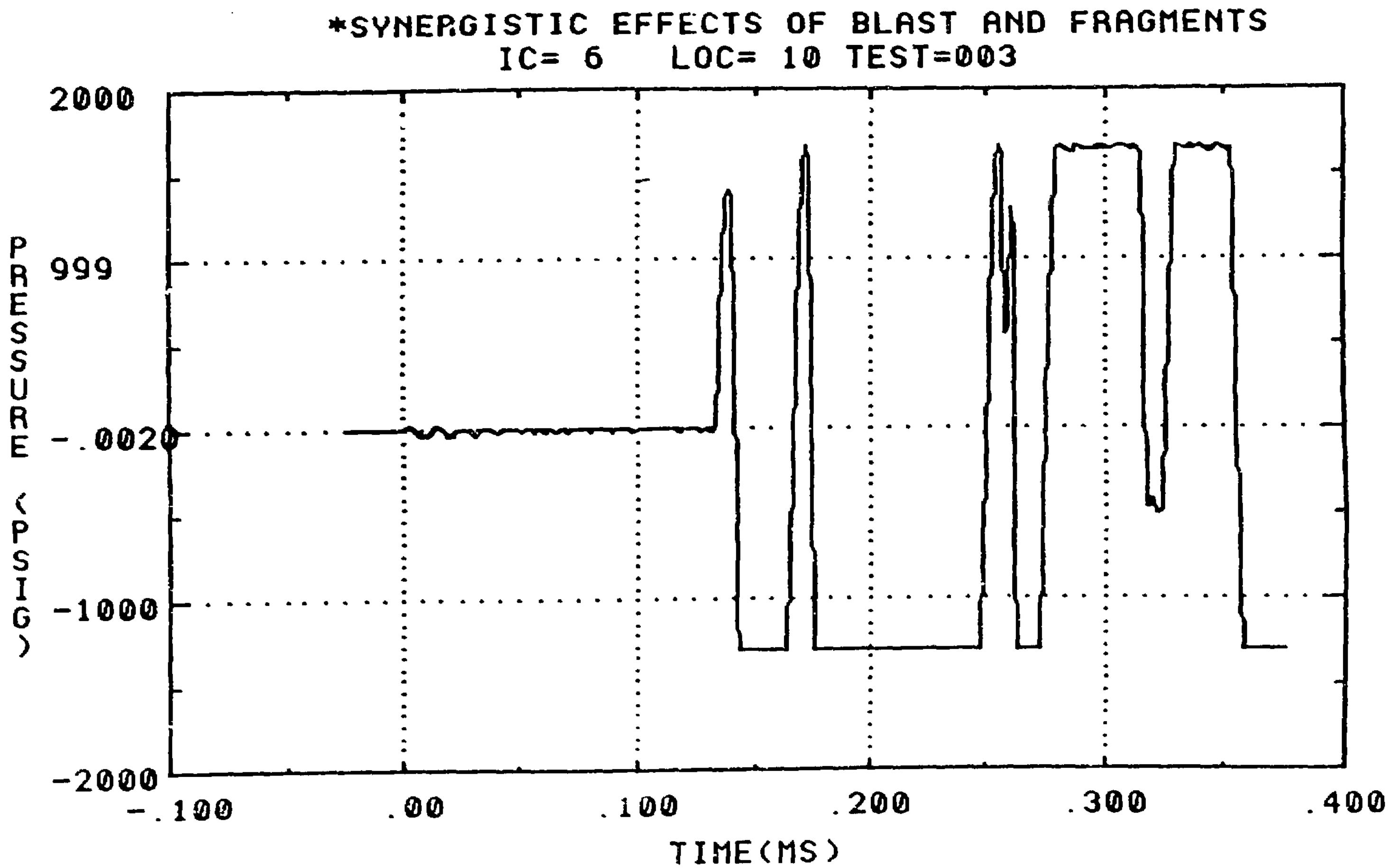


Figure A-27. Loads Test Data, Test 3, LOC 10

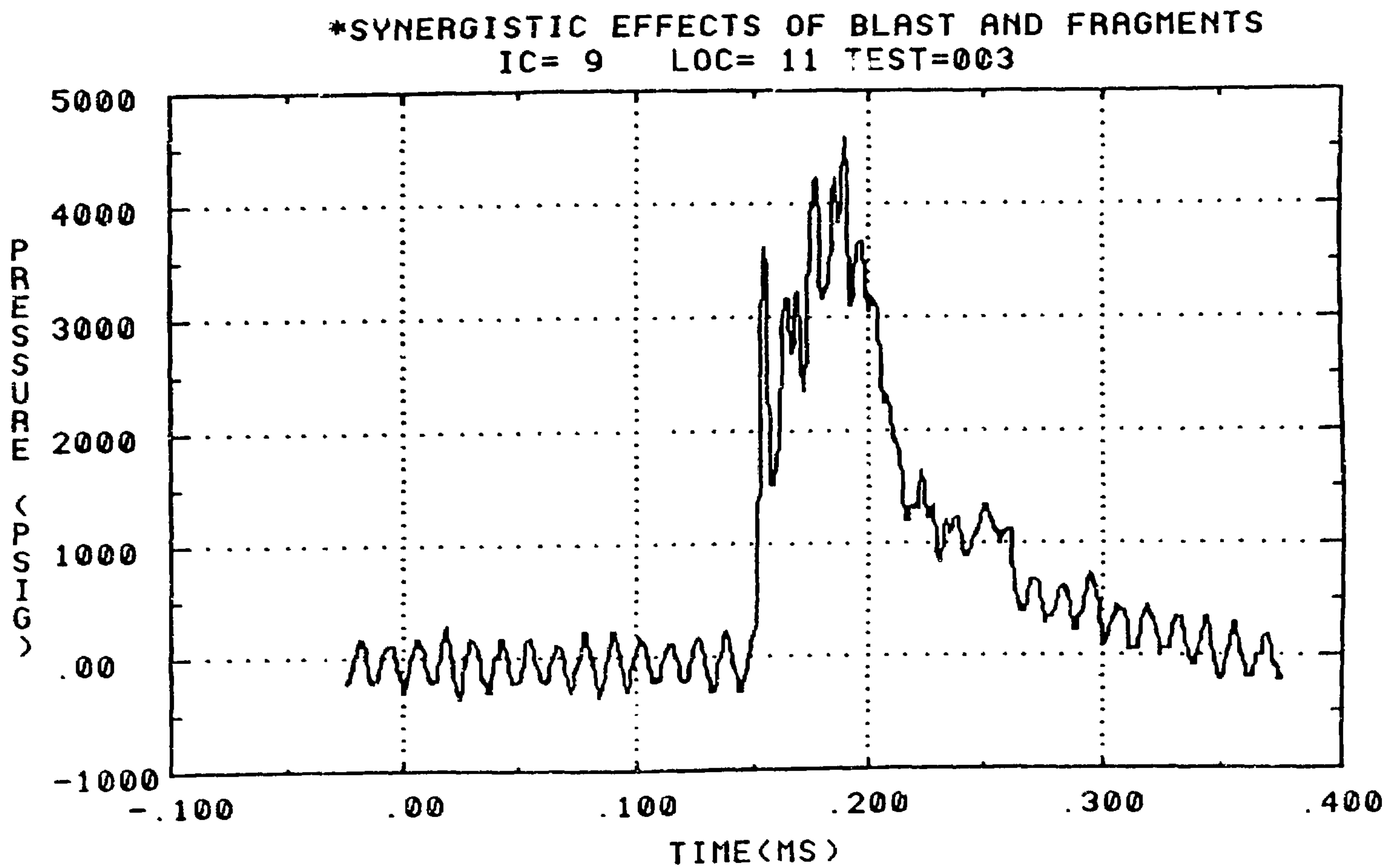


Figure A-28. Loads Test Data, Test 3, LOC 11

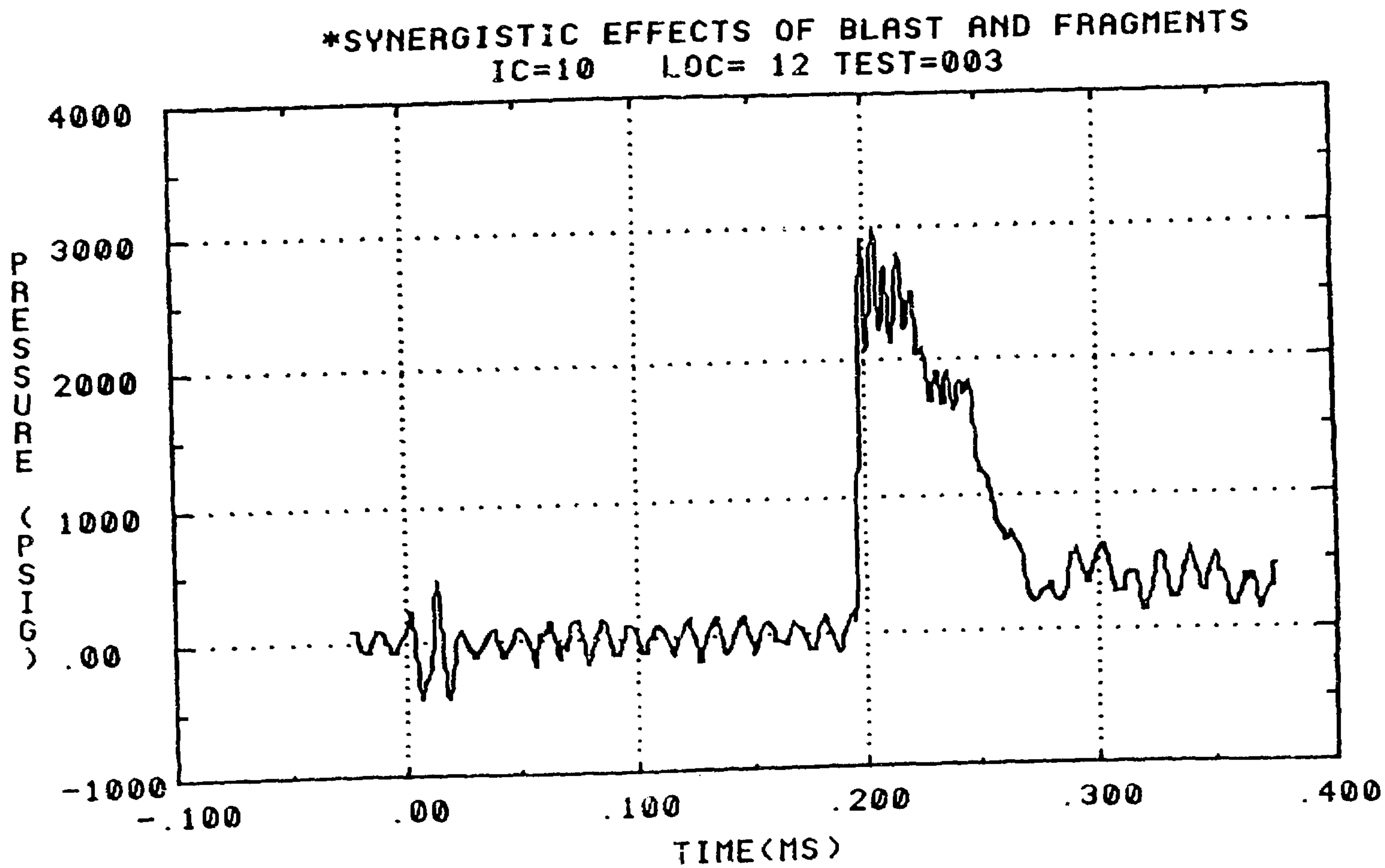


Figure A-29. Loads Test Data, Test 3, LOC 12

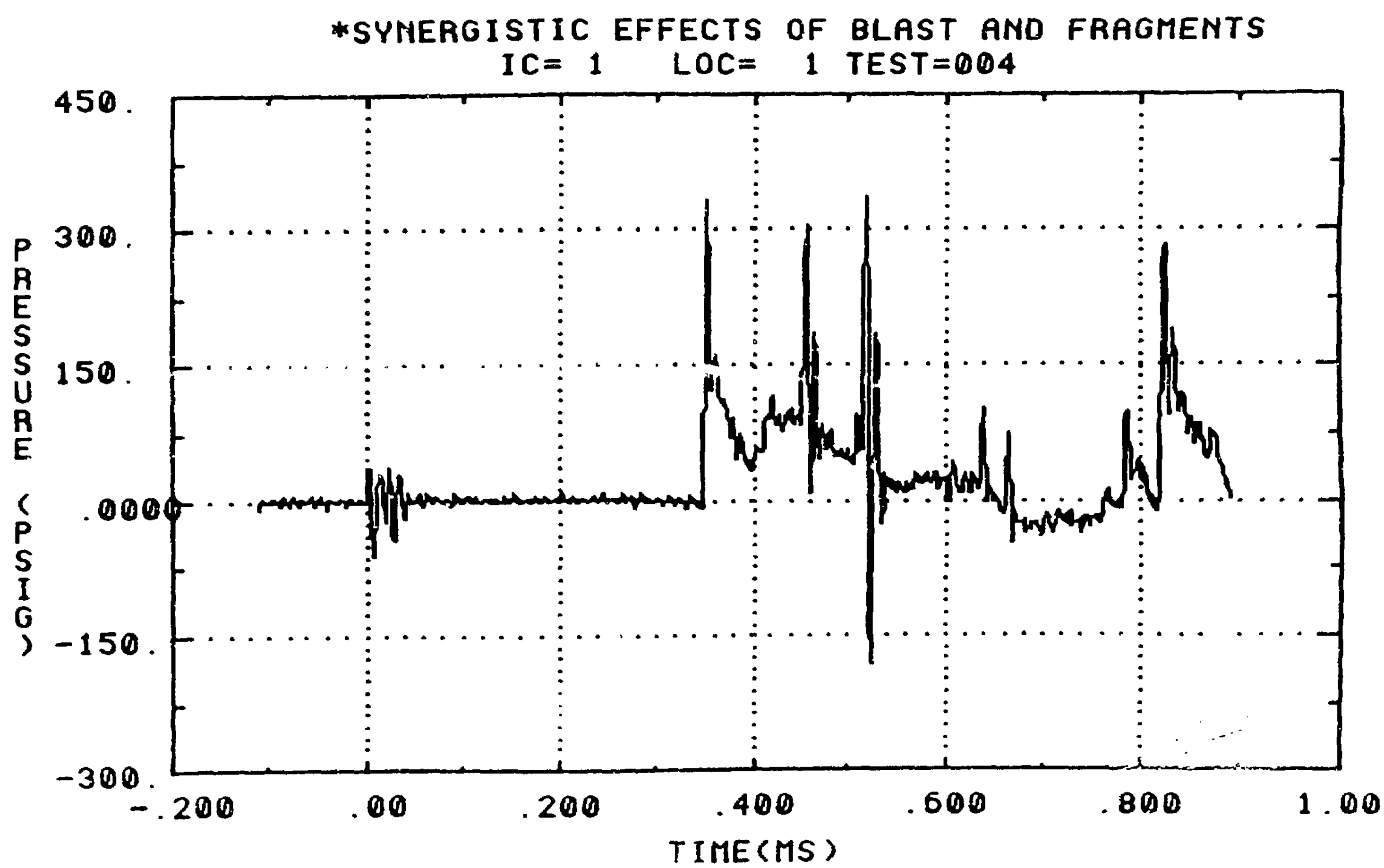


Figure A-30. Loads Test Data, Test 4, LOC 1

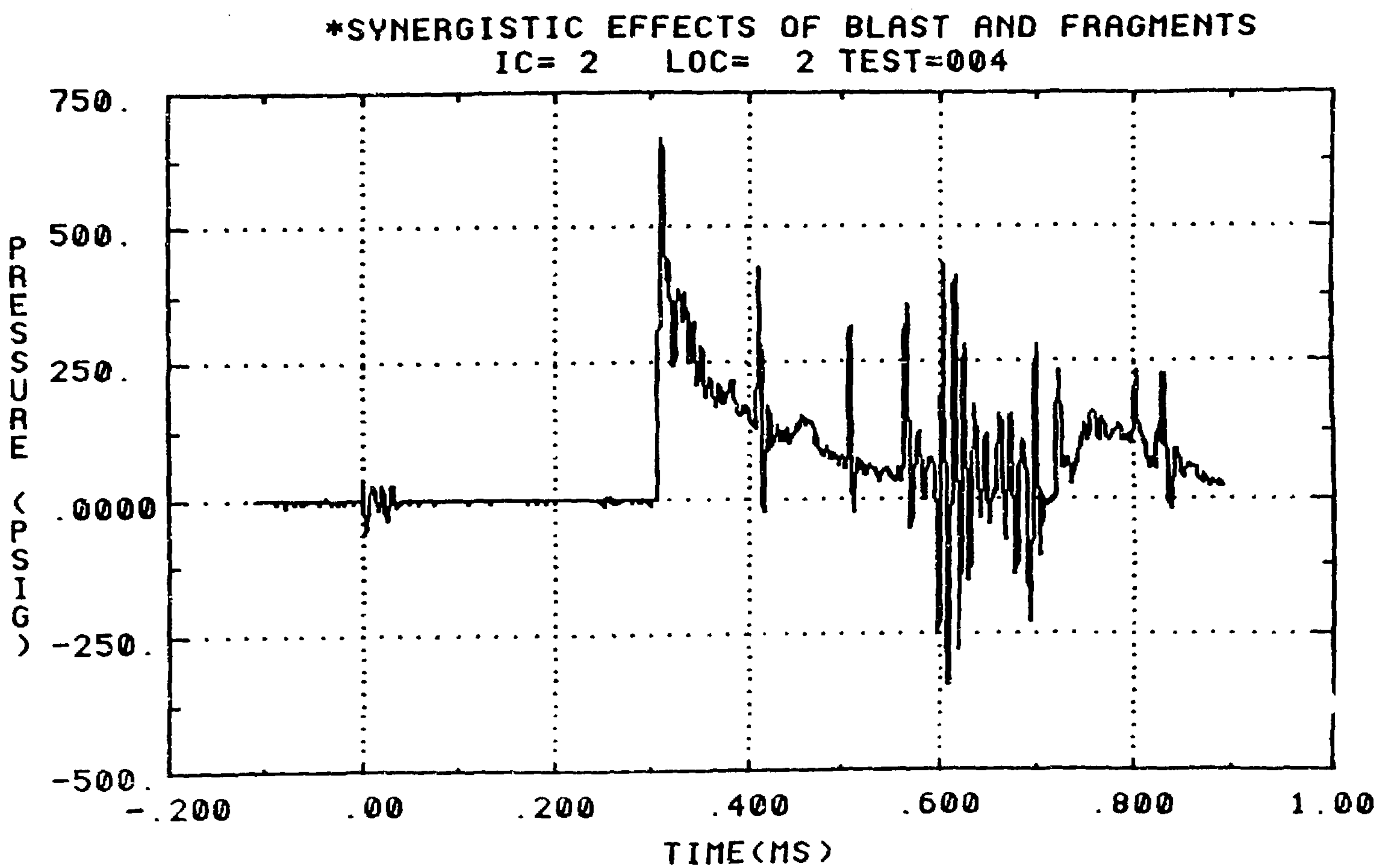


Figure A-31. Loads Test Data, Test 4, LOC 2

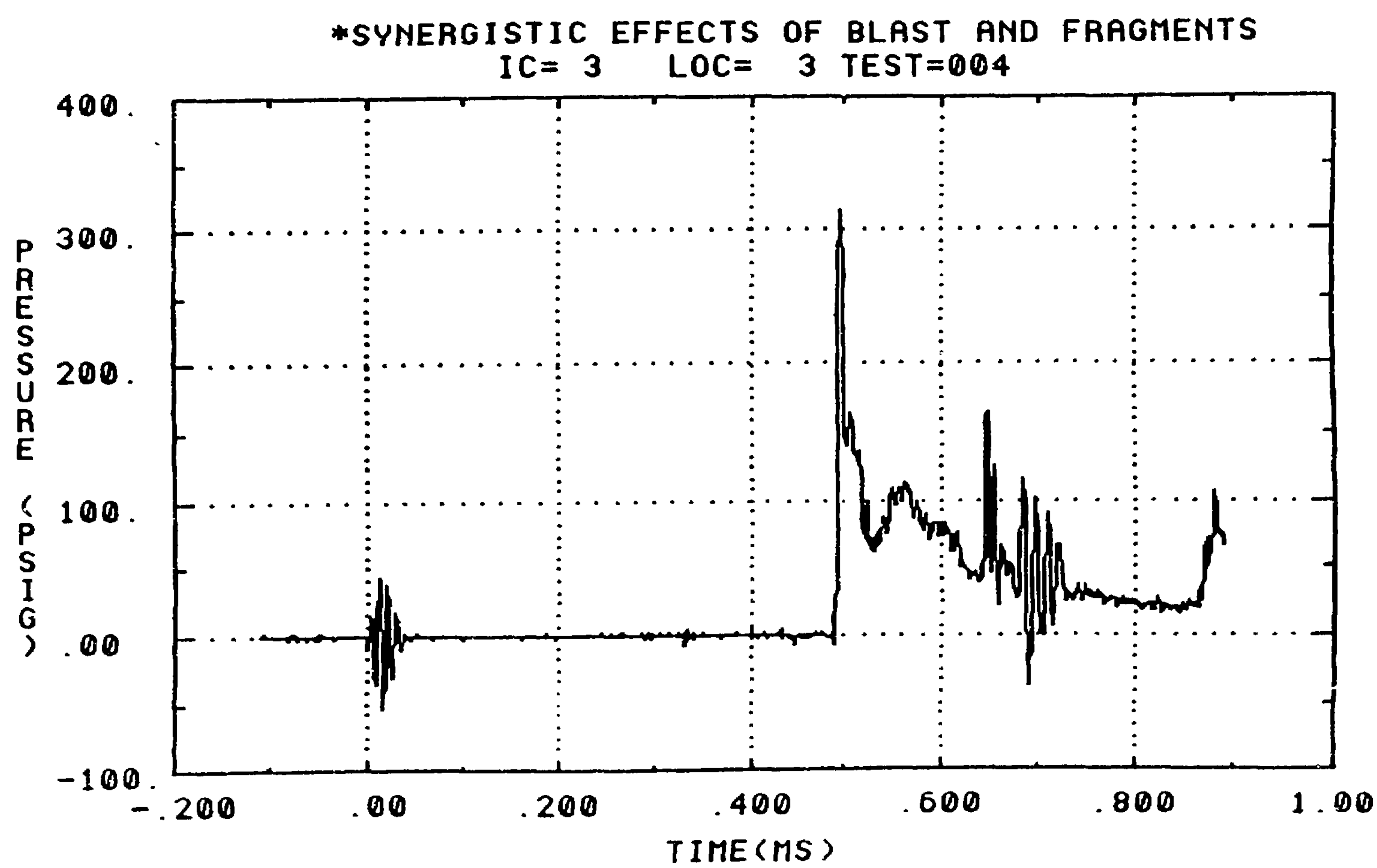


Figure A-32. Loads Test Data, Test 4, LOC 3

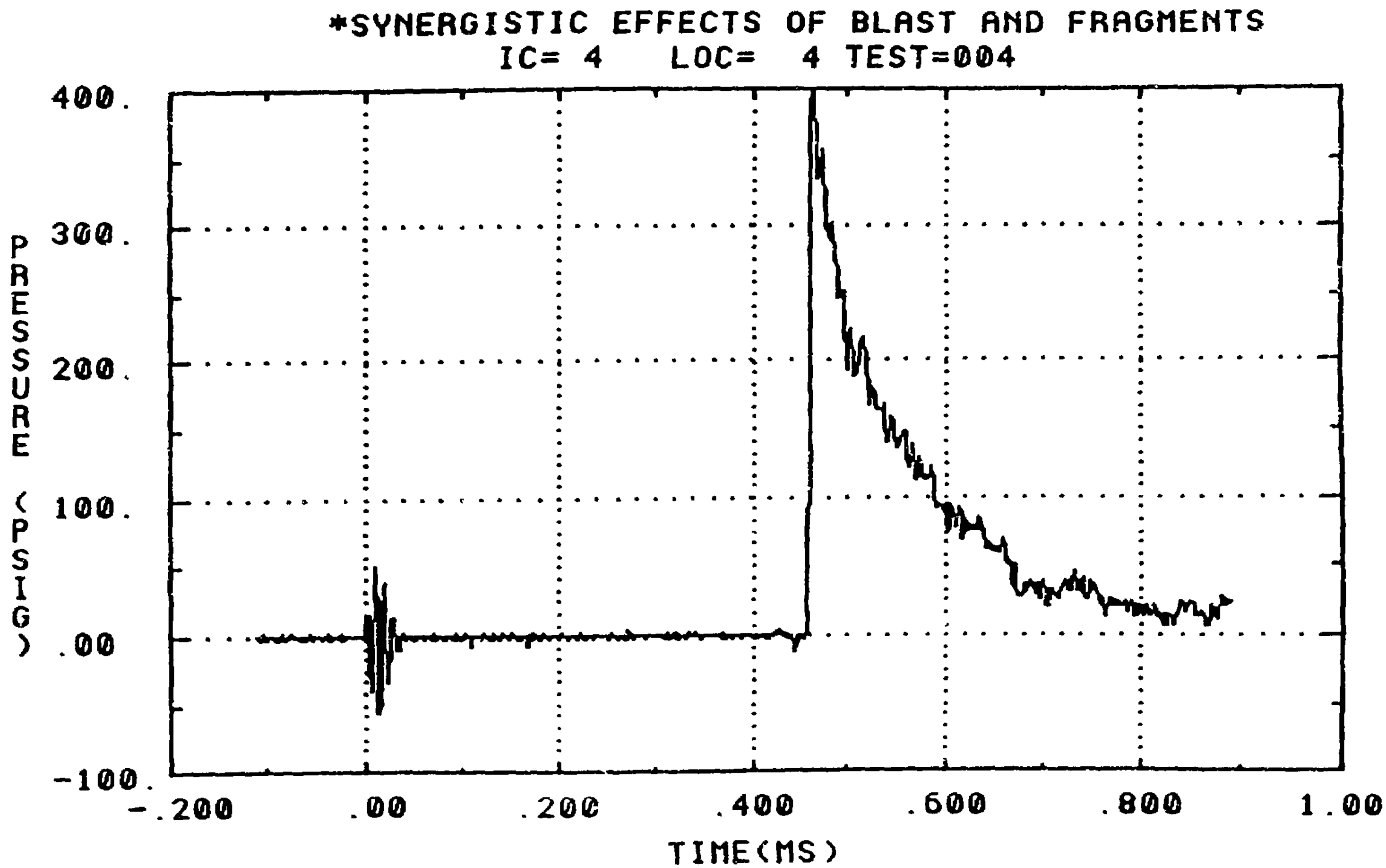


Figure A-33. Loads Test Data, Test 4, LOC 4

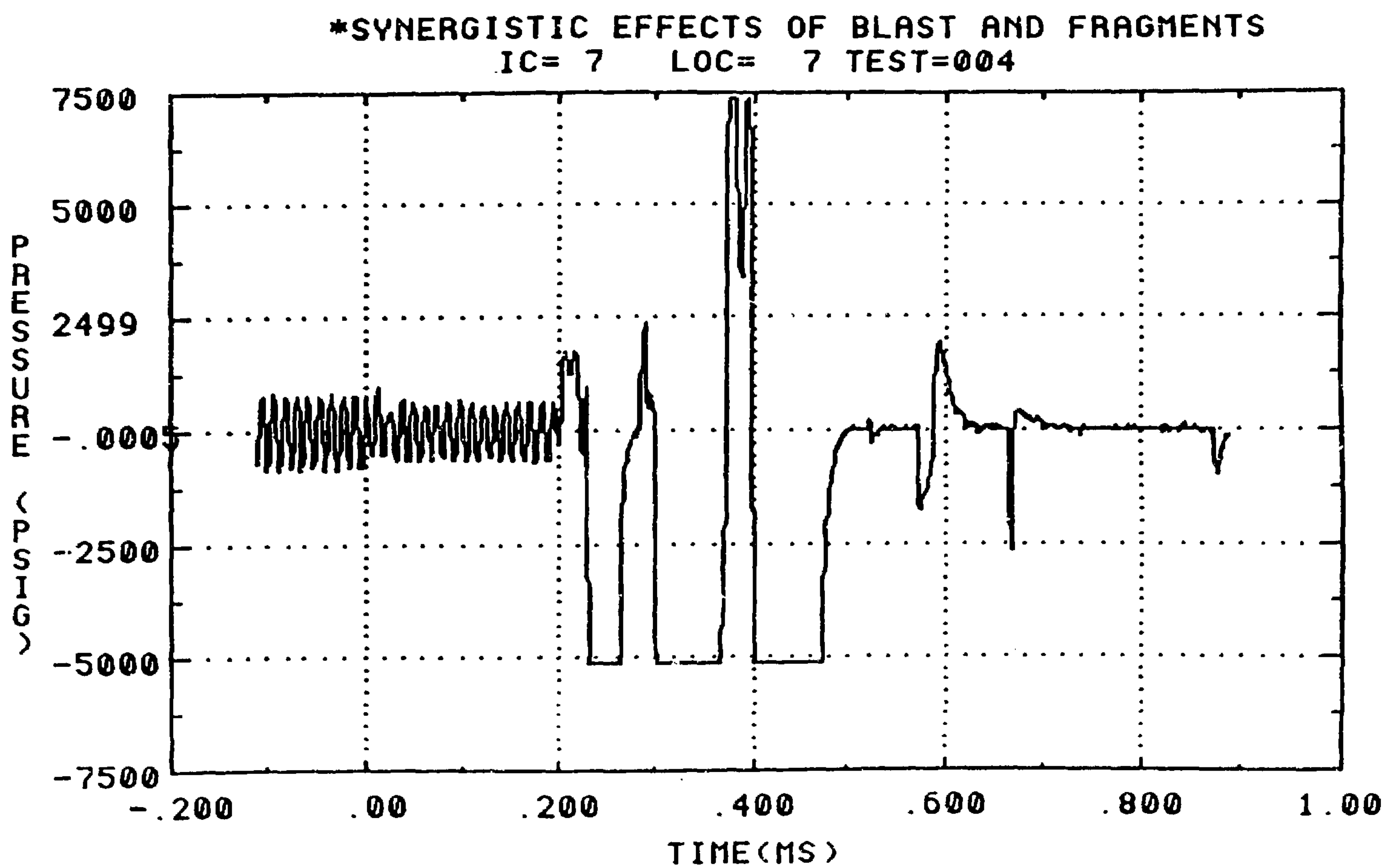


Figure A-34. Loads Test Data, Test 4, LOC 7

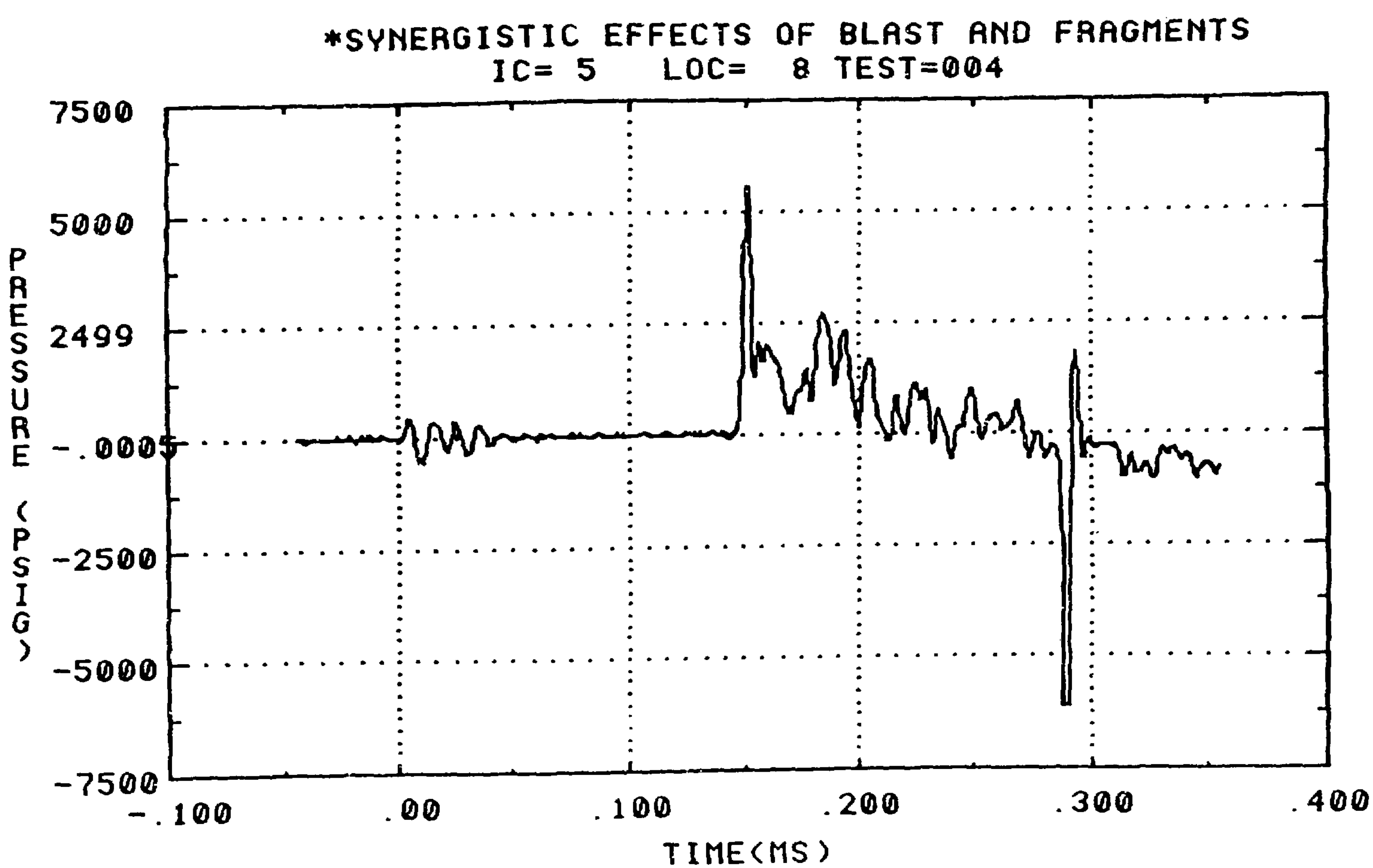


Figure A-35. Loads Test Data, Test 4, LOC 8

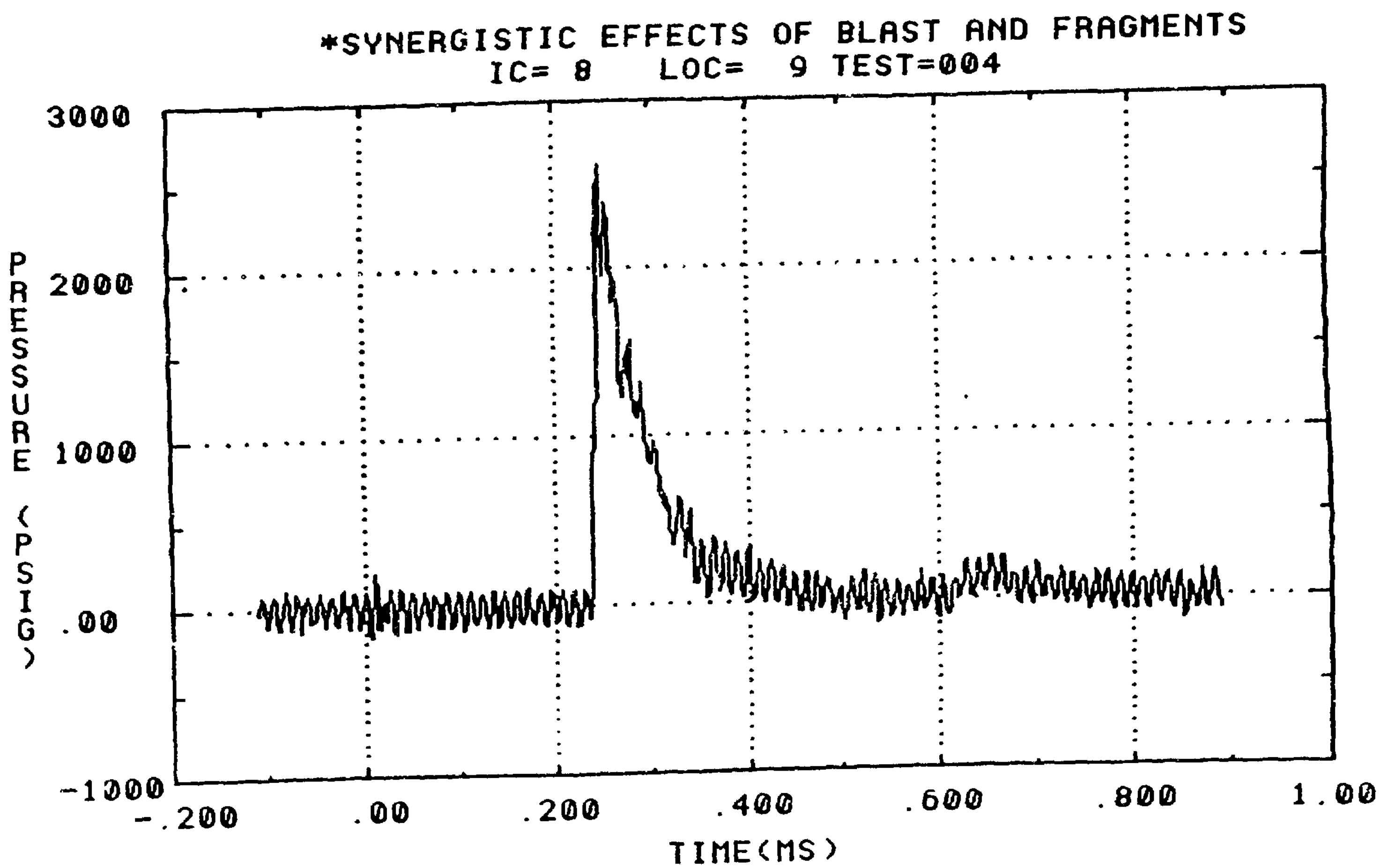


Figure A-36. Loads Test Data, Test 4, LOC 9

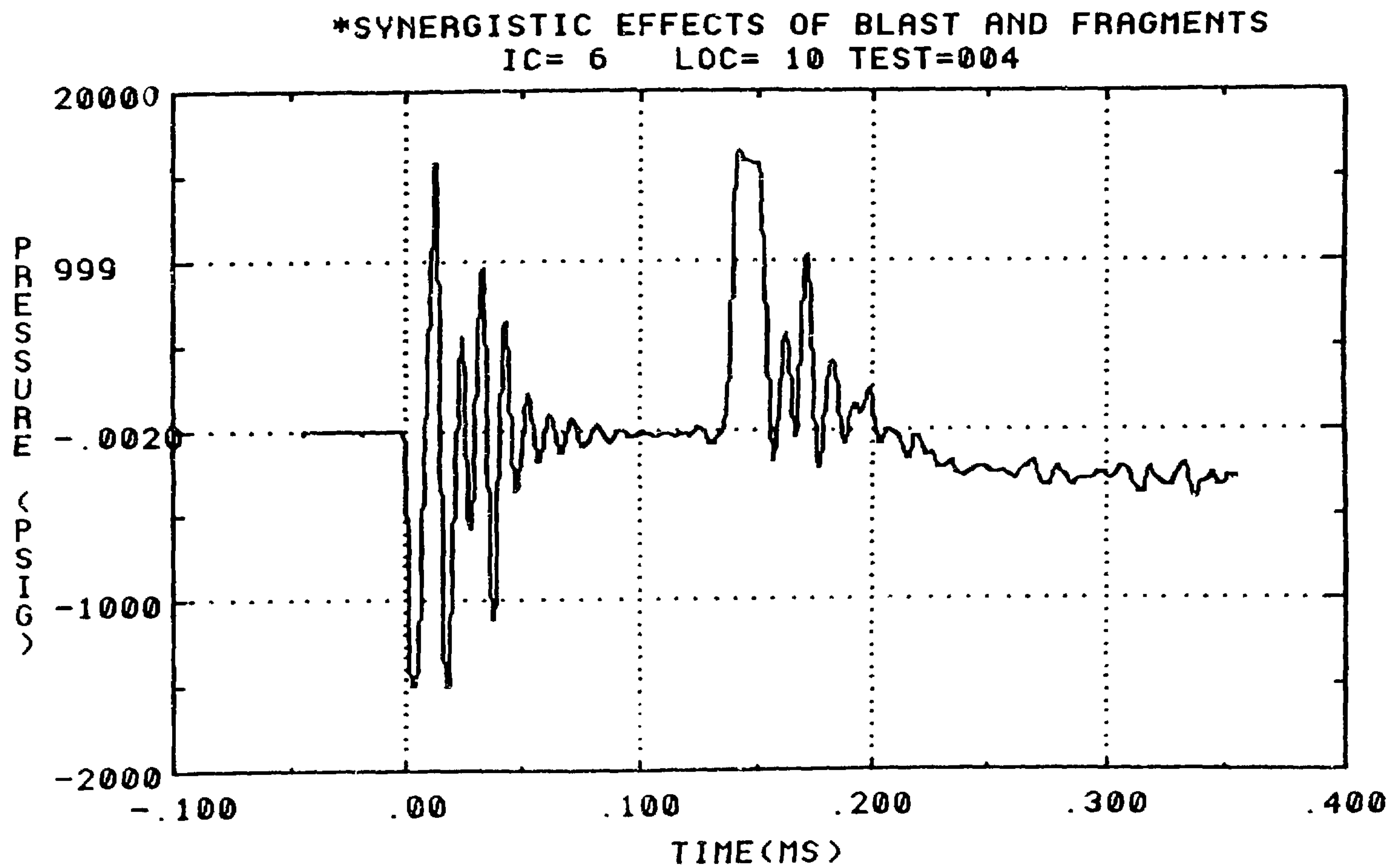


Figure A-37. Loads Test Data, Test 4, LOC 10

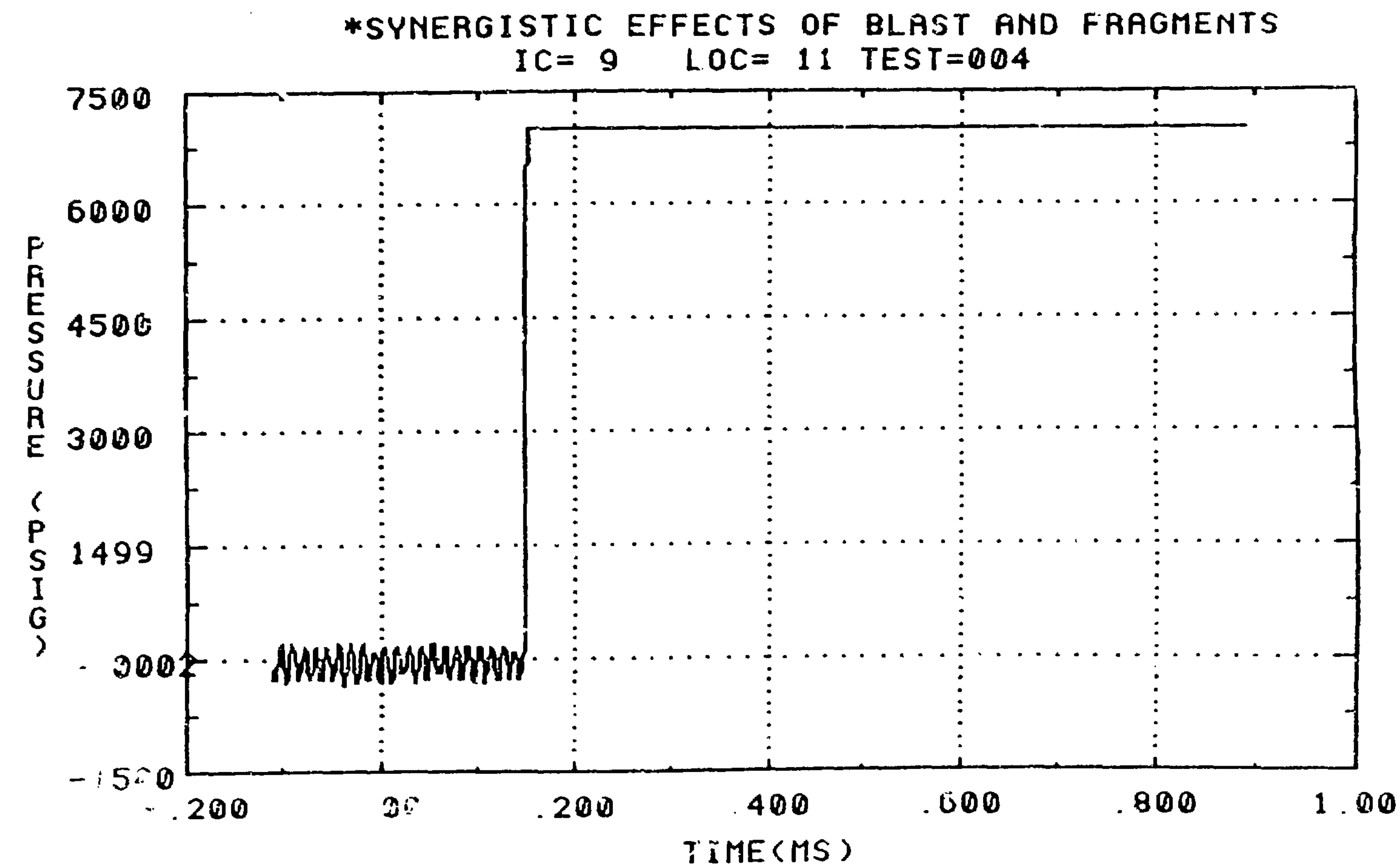


Figure A-38. Loads Test Data, Test 4, LOC 11

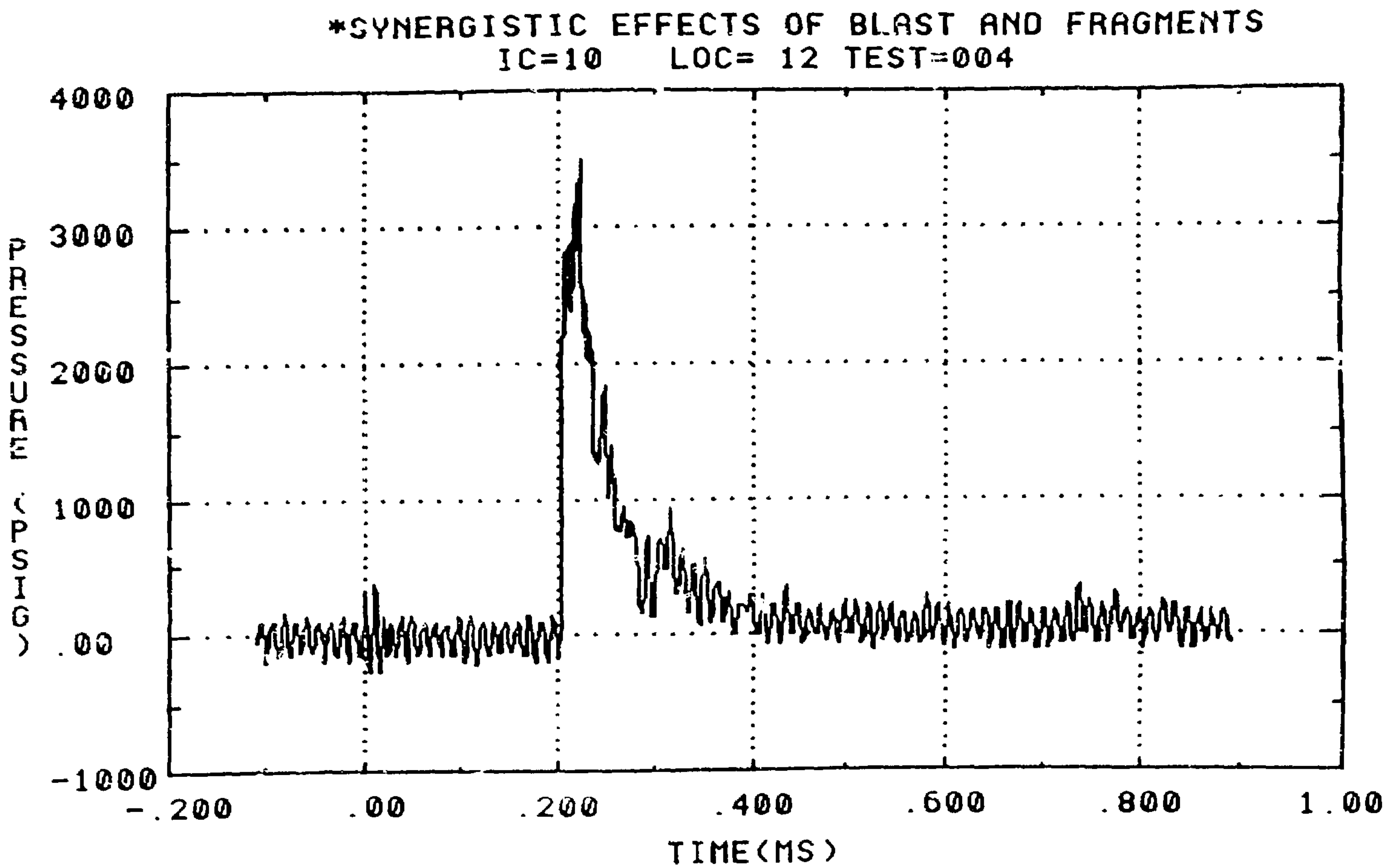


Figure A-39. Loads Test Data, Test 4, LOC 12

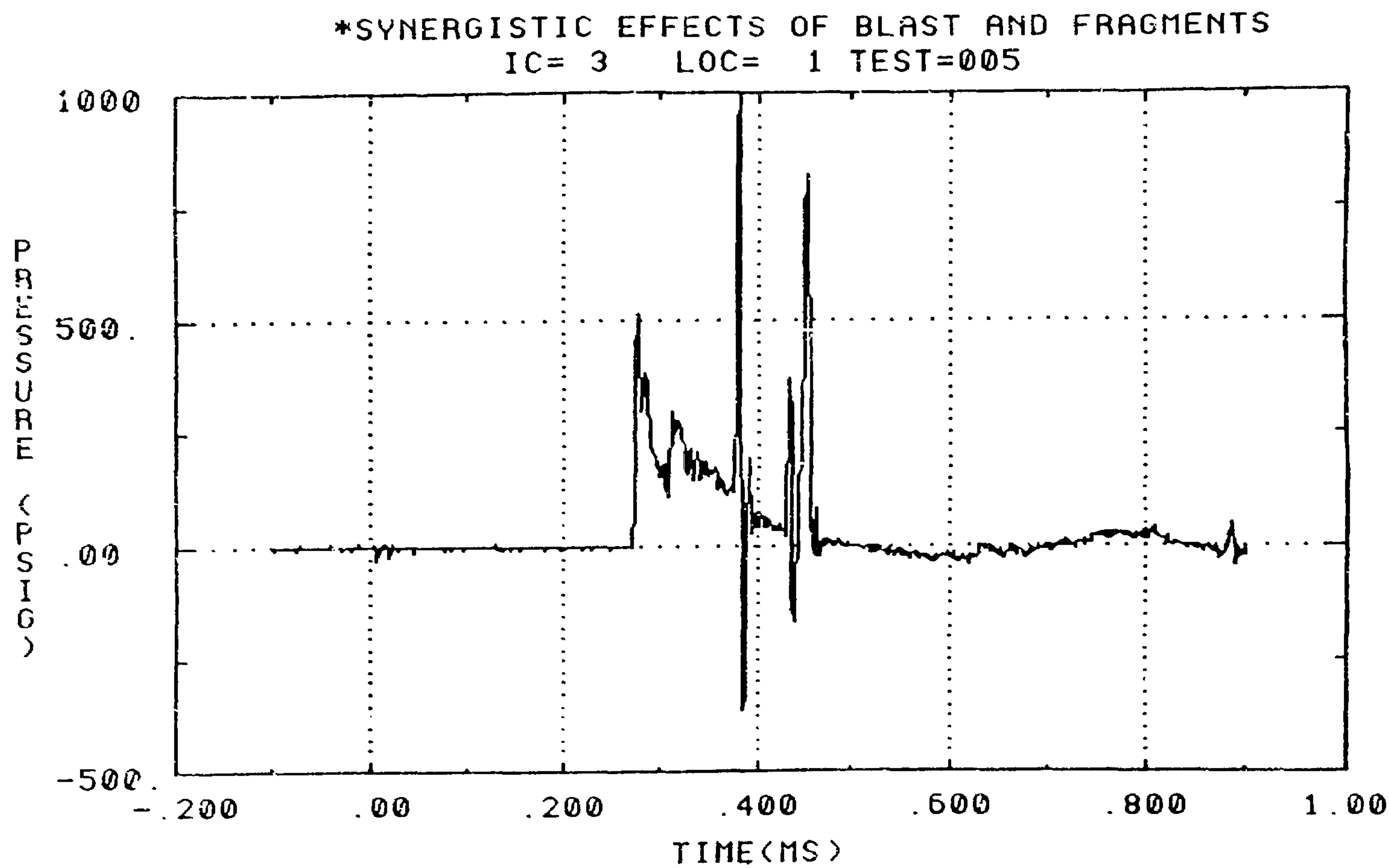


Figure A-40. Loads Test Data, Test 5, LOC 1

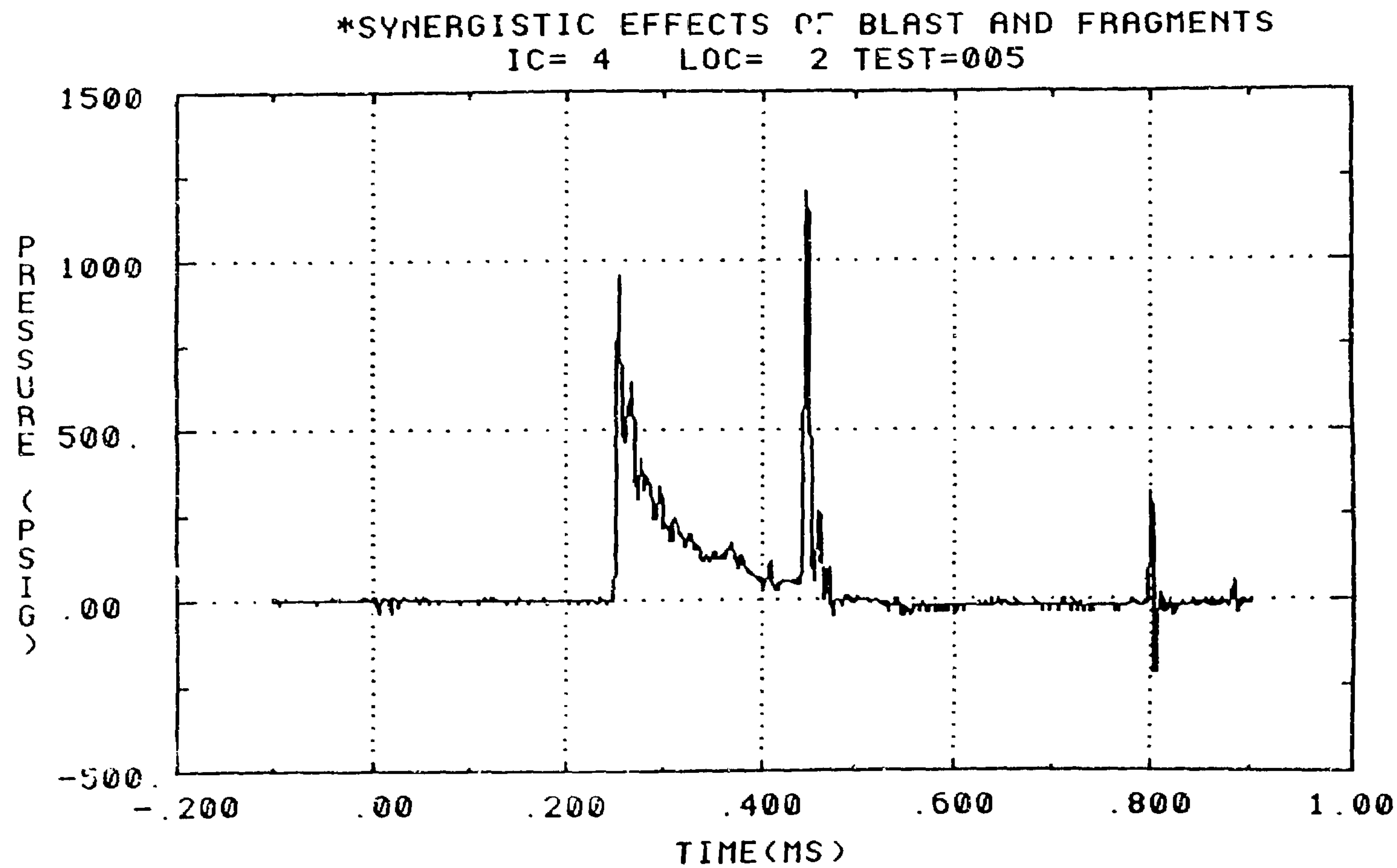


Figure A-41. Loads Test Data, Test 5, LOC 2

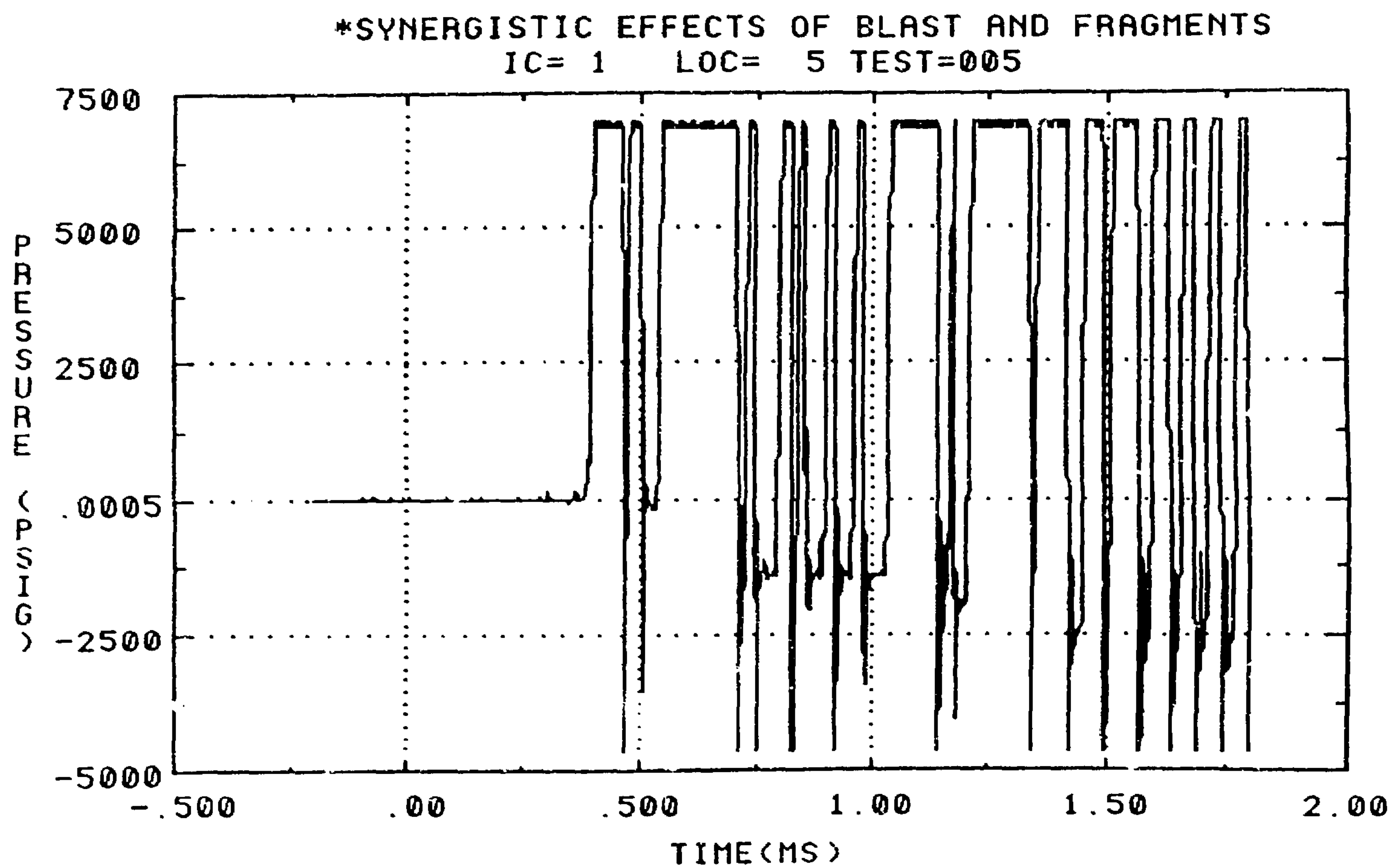


Figure A-42. Loads Test Data, Test 5, LOC 5

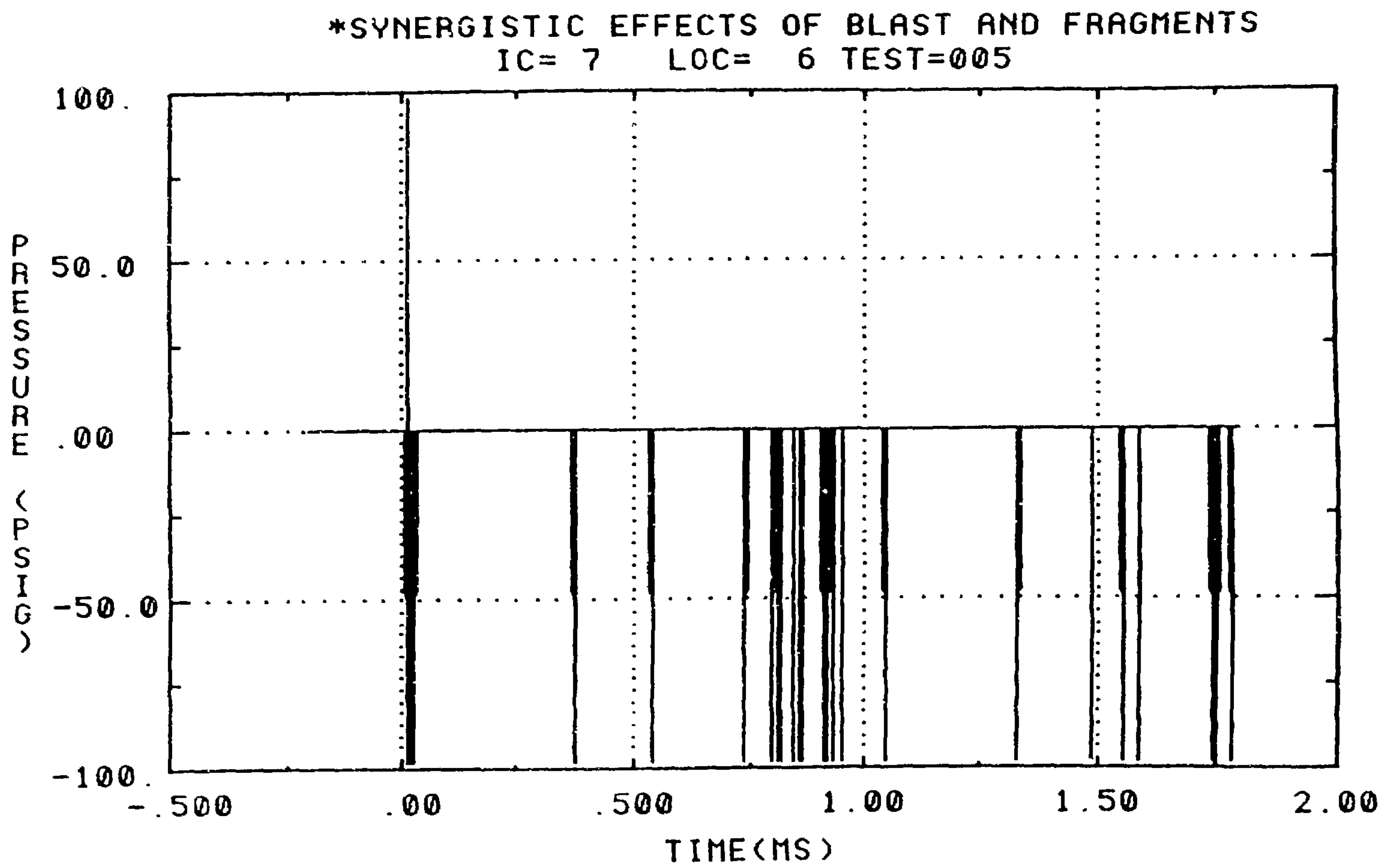


Figure A-43. Loads Test Data, Test 5, LOC 6

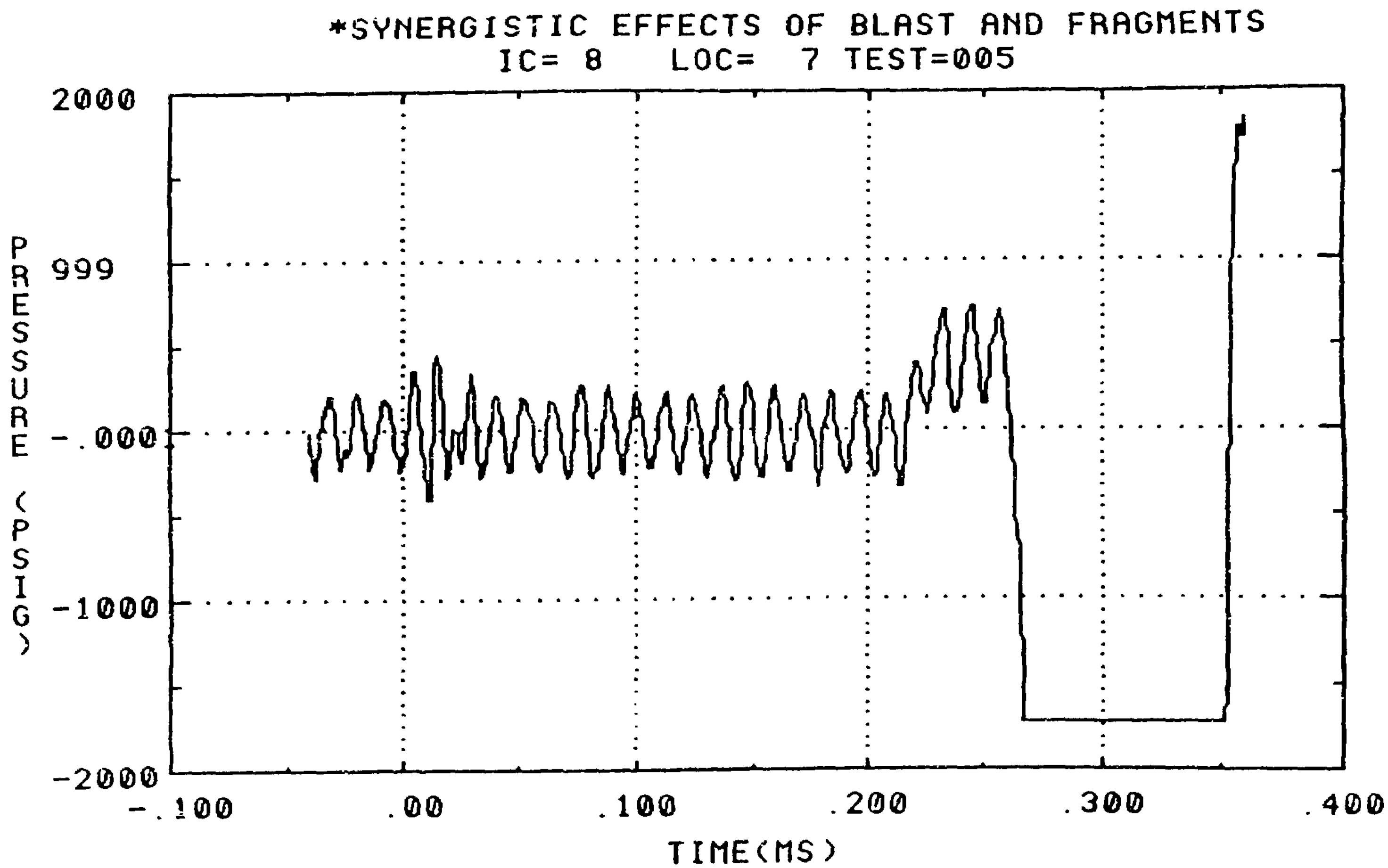


Figure A-44. Loads Test Data, Test 5, LOC 7

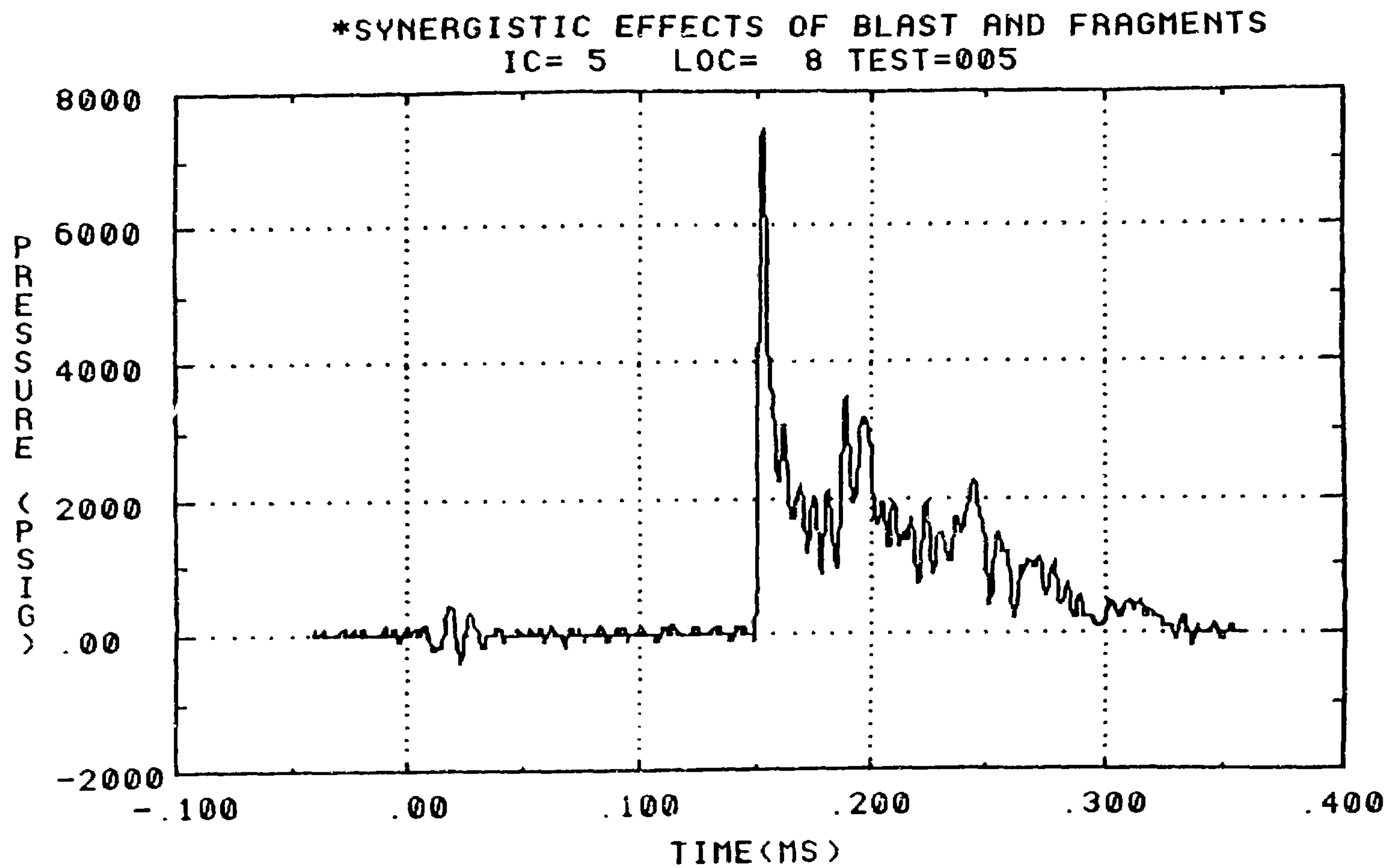


Figure A-45. Loads Test Data, Test 5, LOC 8

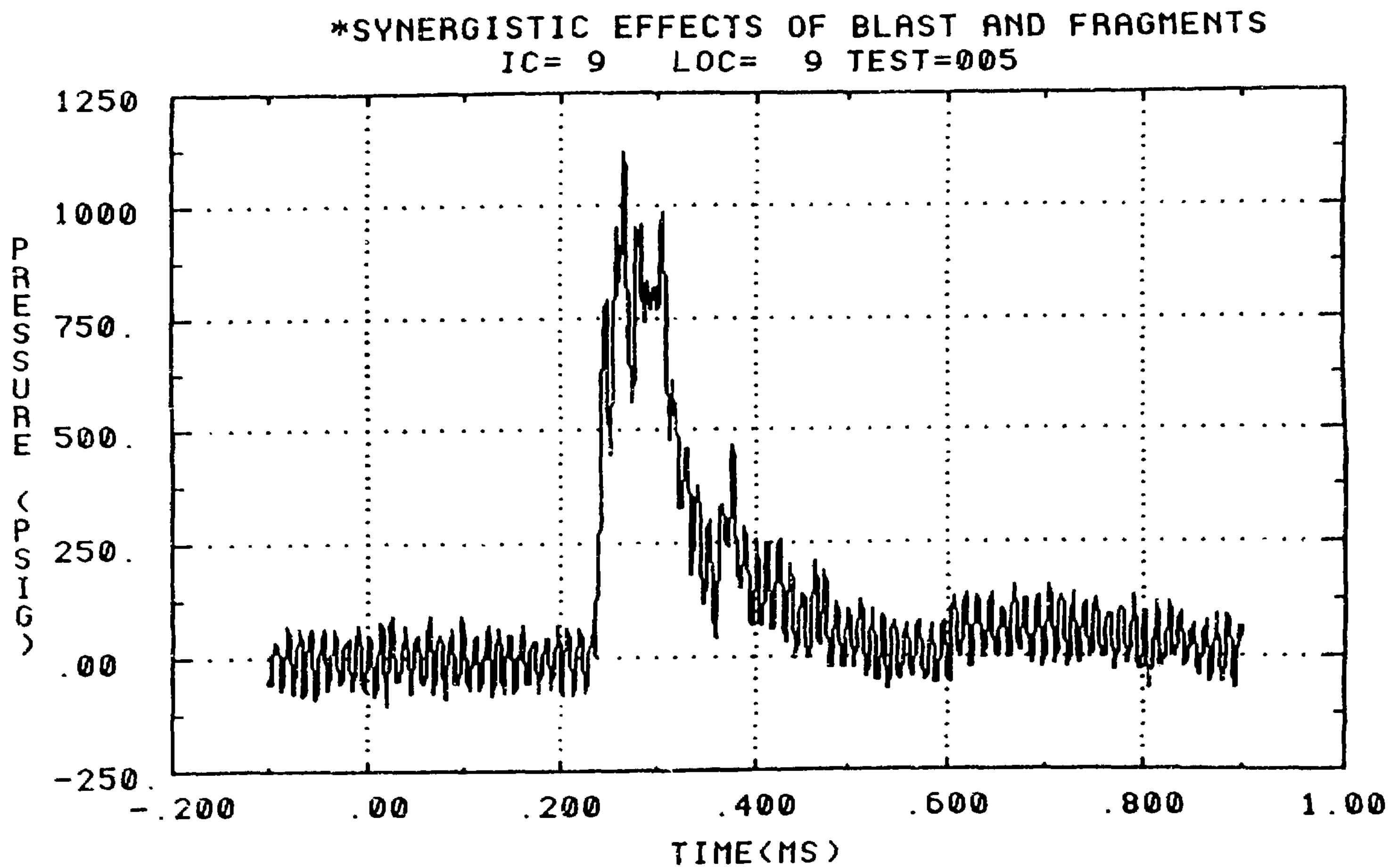


Figure A-46. Loads Test Data, Test 5, LOC 9

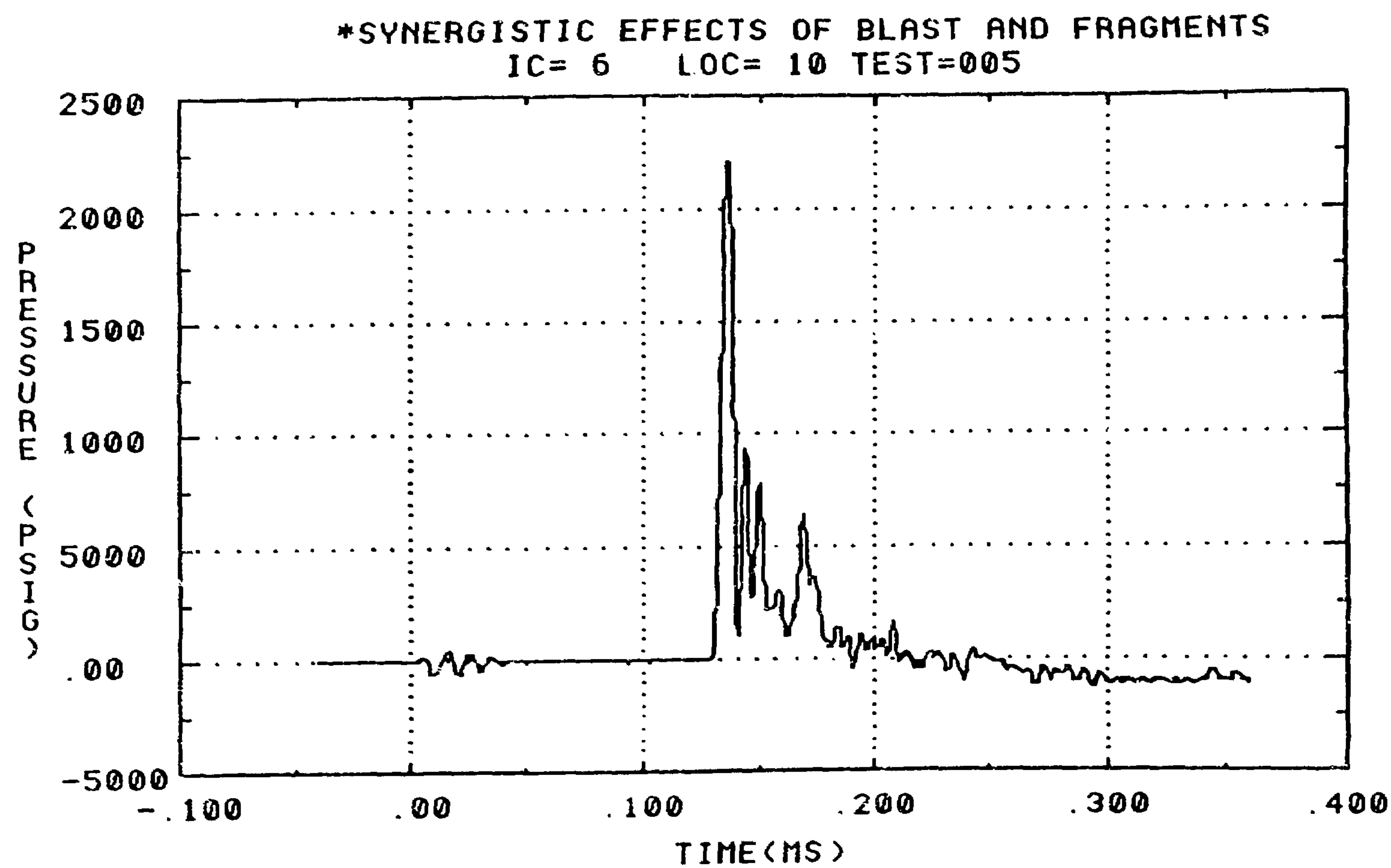


Figure A-47. Loads Test Data, Test 5, LOC 10

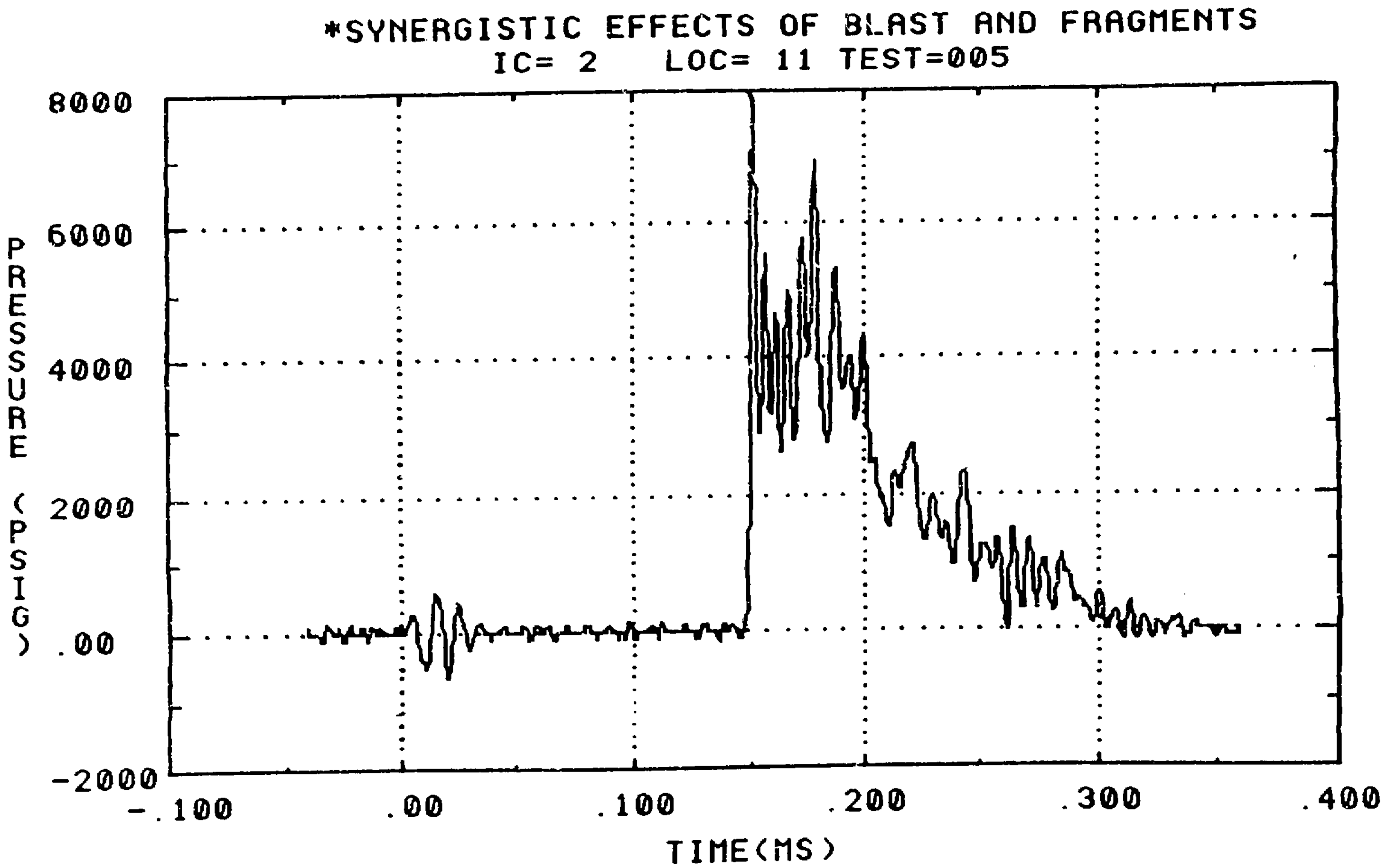


Figure A-48. Loads Test Data, Test 5, LOC 11

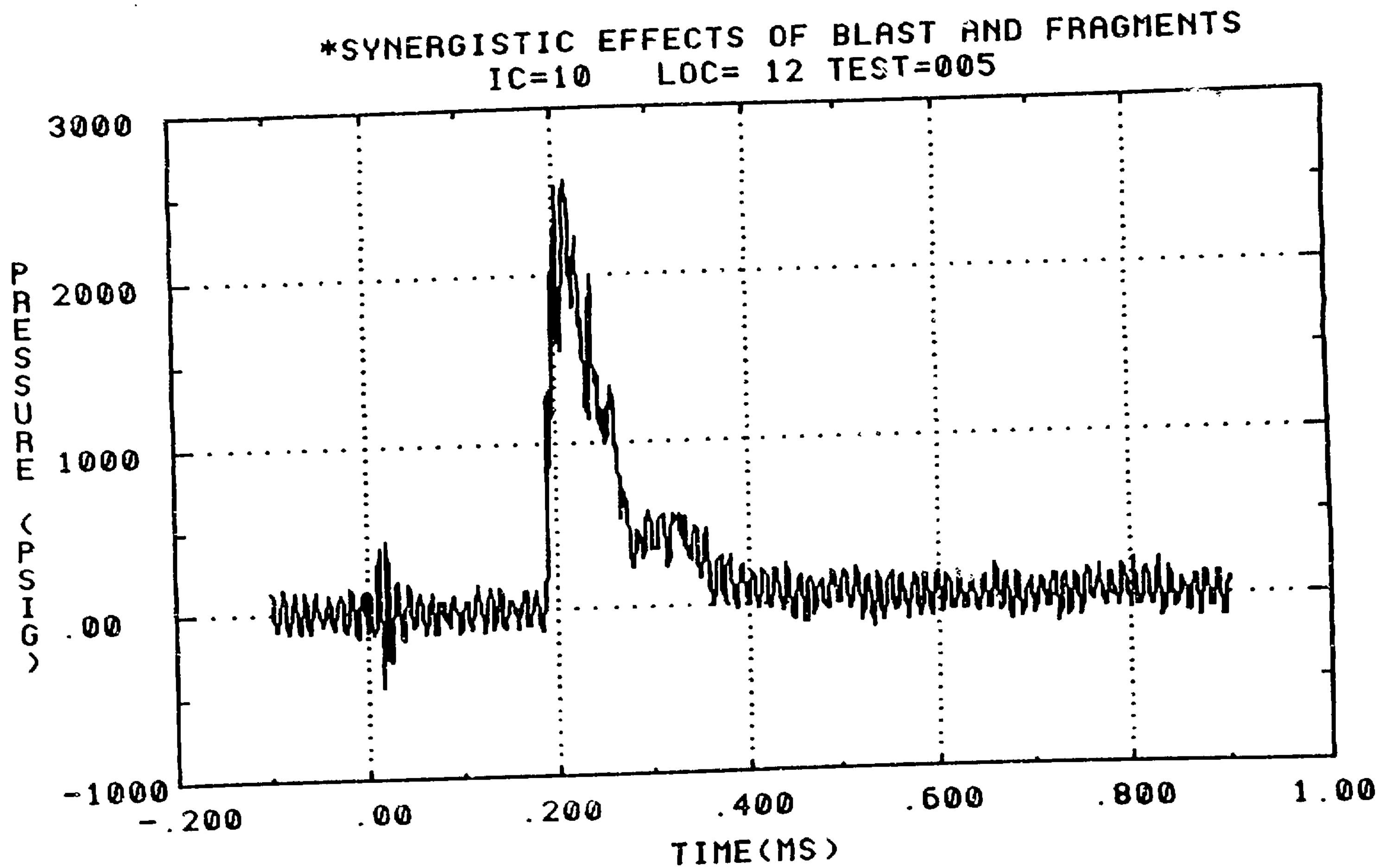


Figure A-49. Loads Test Data, Test 5, LOC 12

APPENDIX B

Test Data from Cased Charge Loads Tests

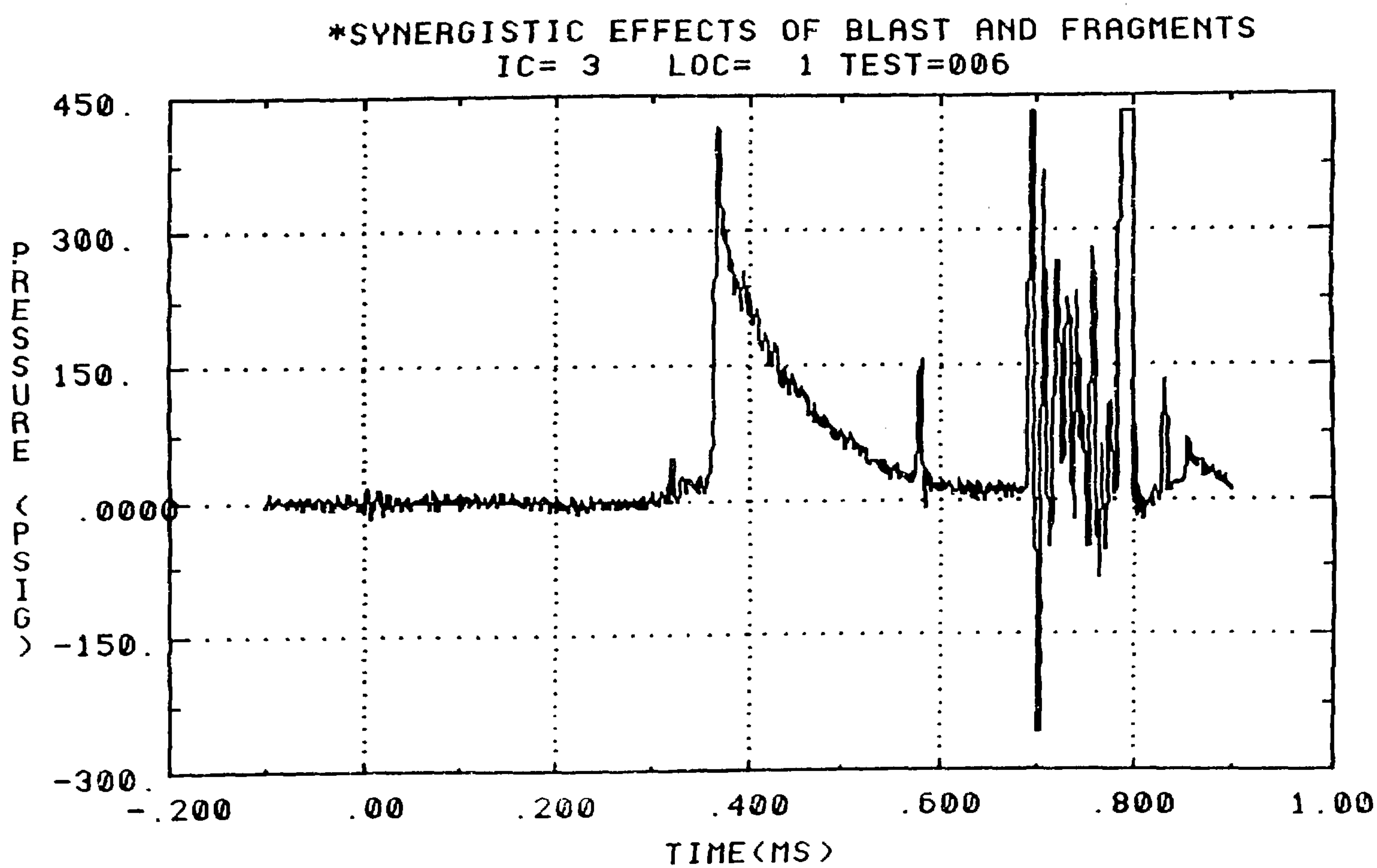


Figure B-1. Loads Test Data, Test 6, LOC 1

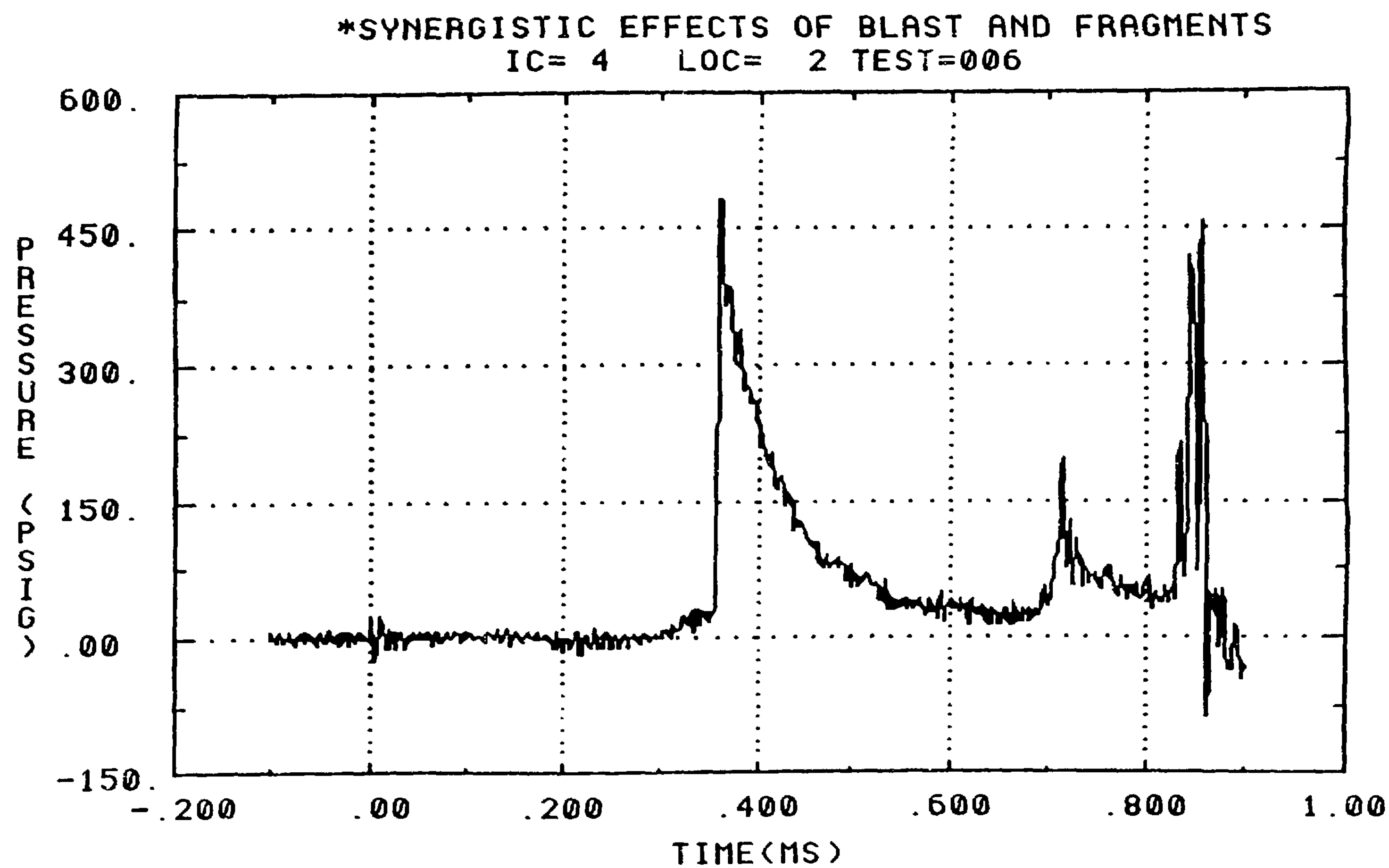


Figure B-2. Loads Test Data, Test 6, LOC 2

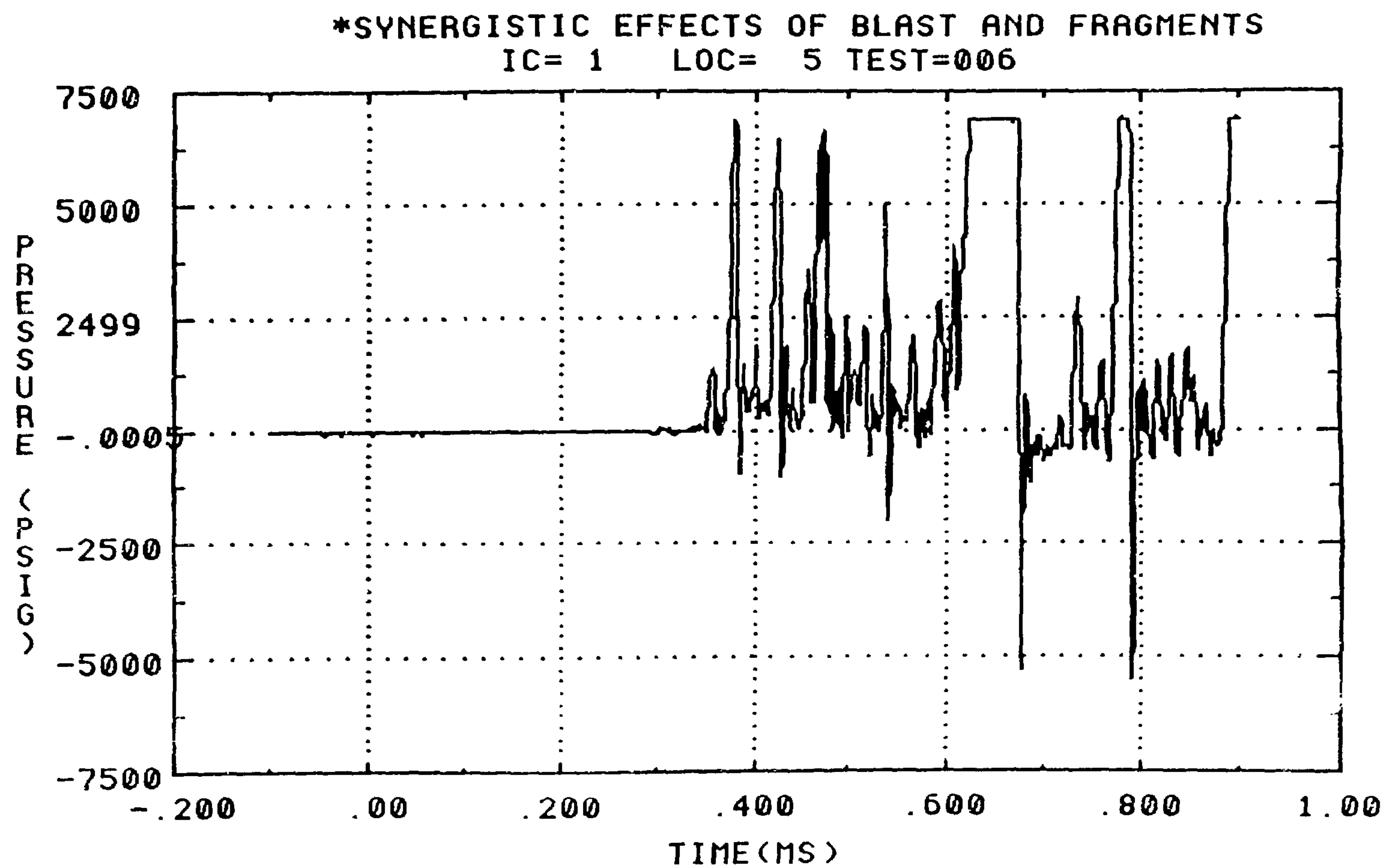


Figure B-3. Loads Test Data, Test 6, LOC 5

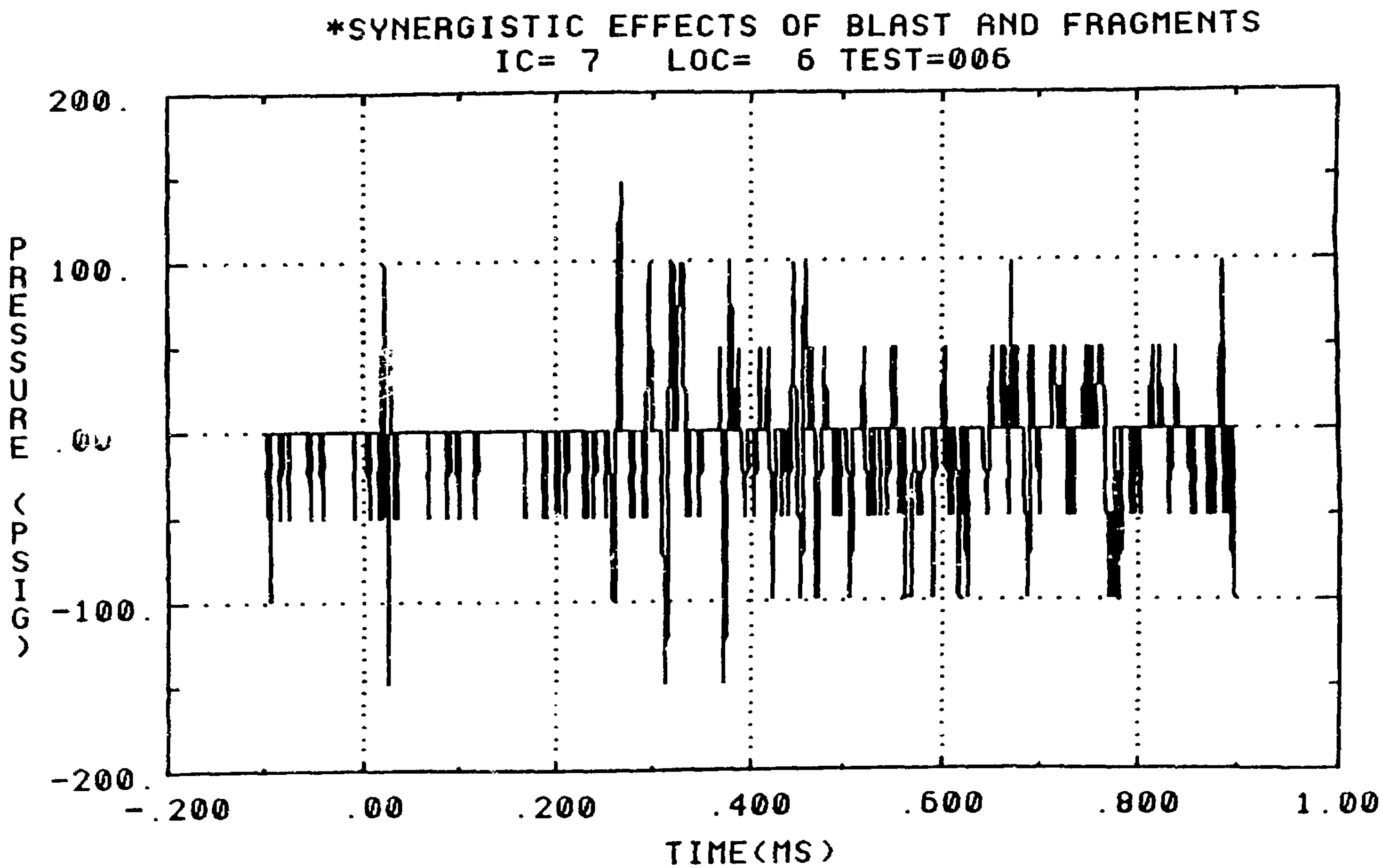


Figure B-4. Loads Test Data, Test 6, LOC 6

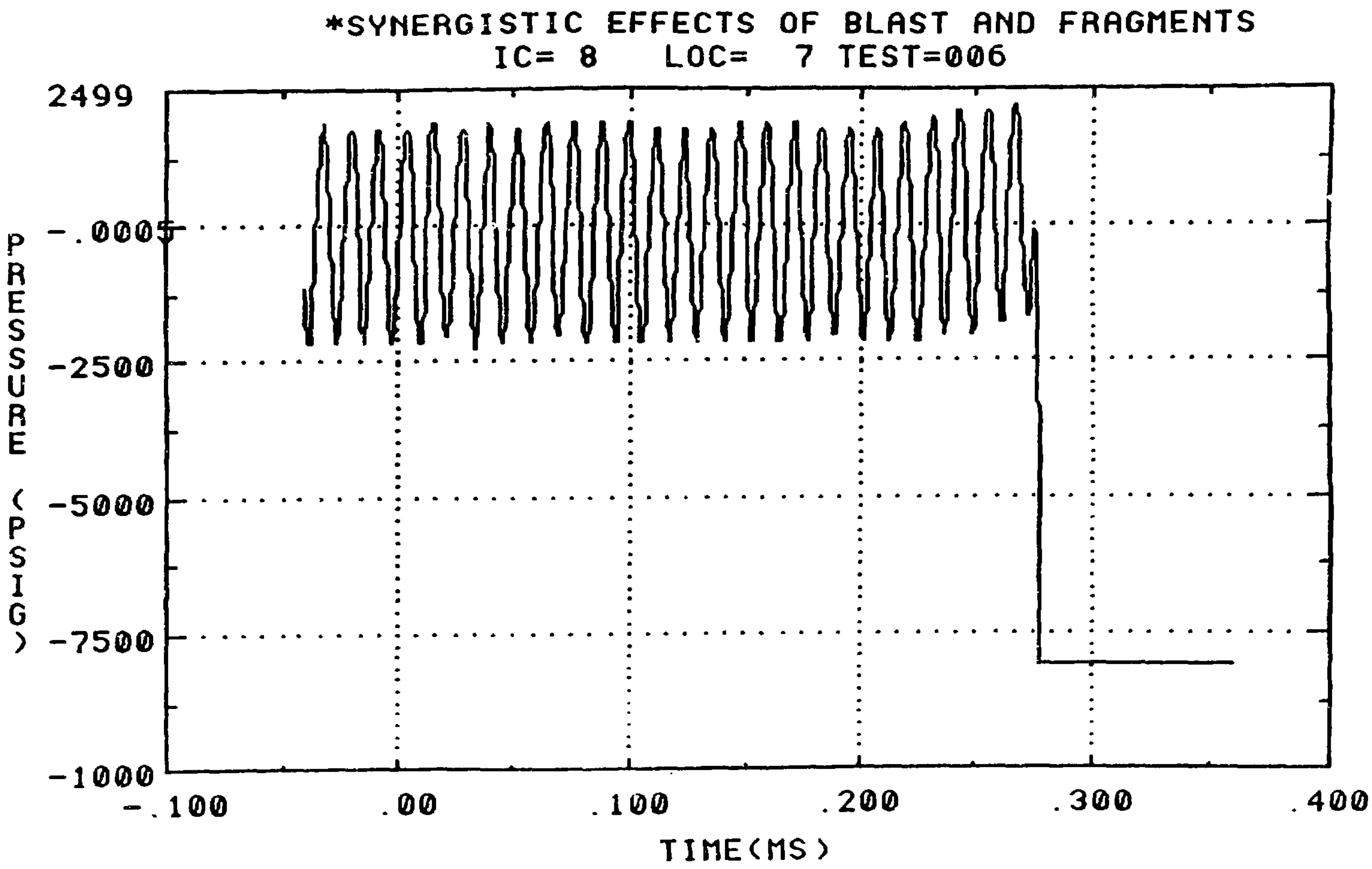


Figure B-5. Loads Test Data, Test 6, LOC 7

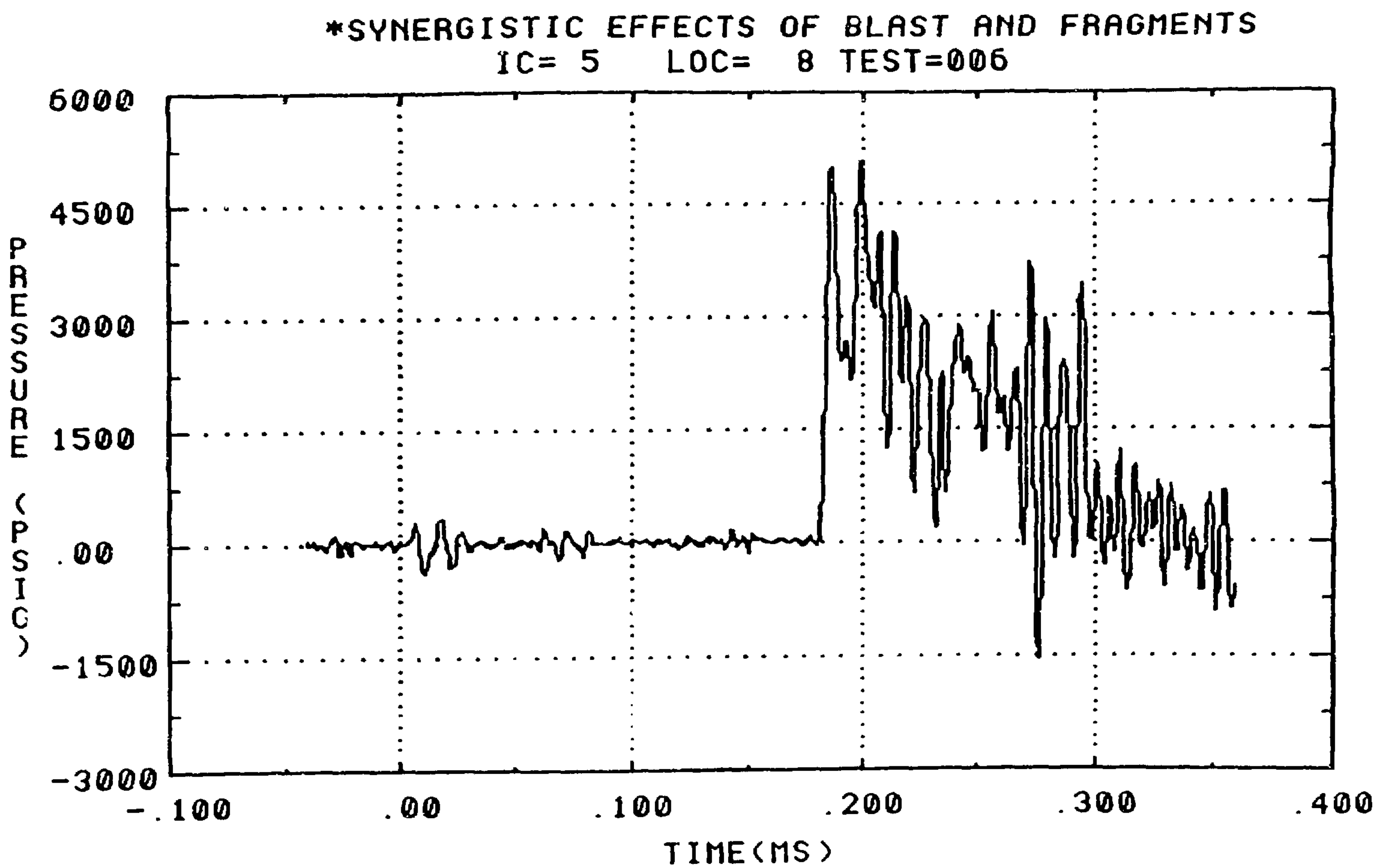


Figure B-6. Loads Test Data, Test 6, LOC 8

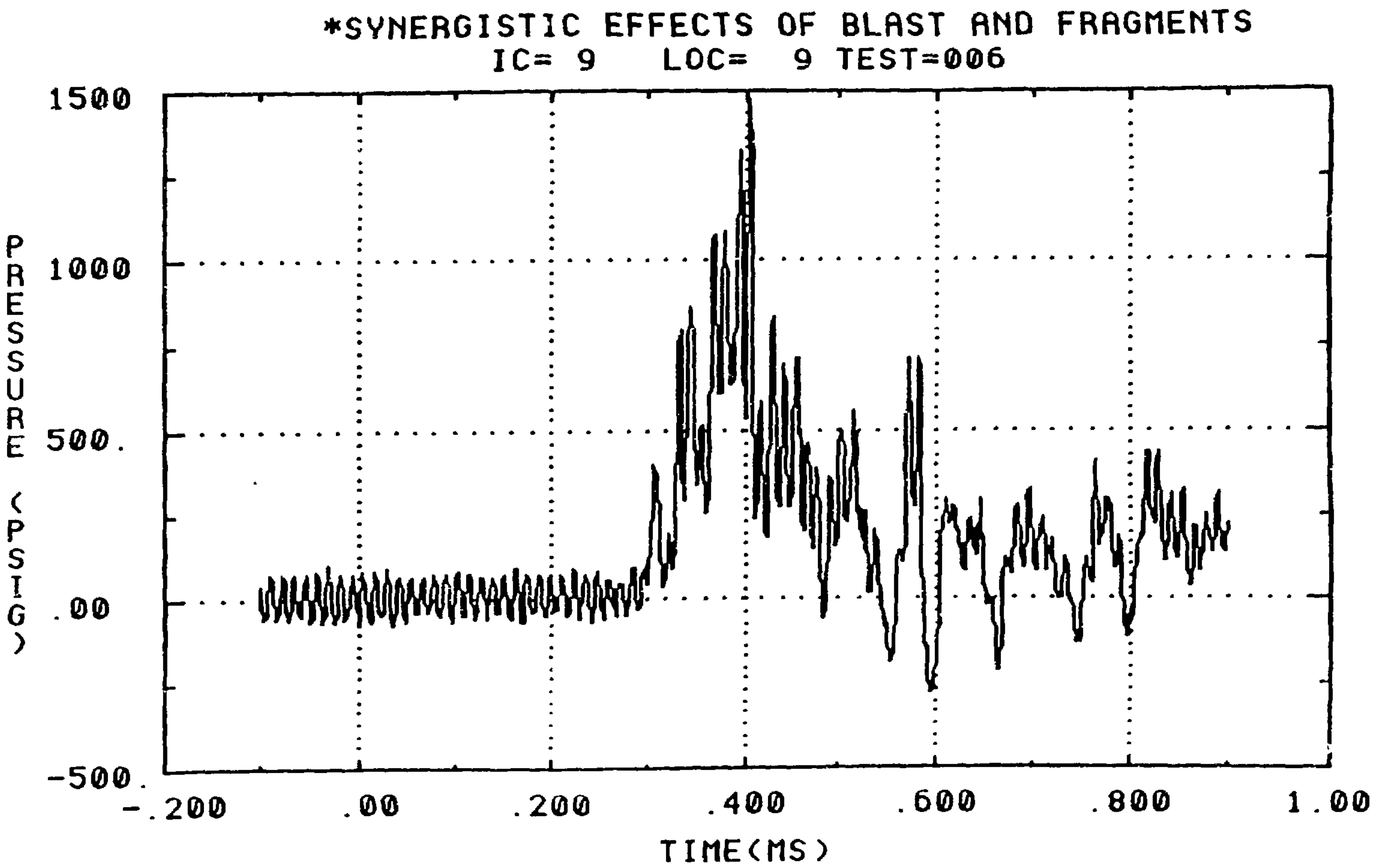


Figure B-7. Loads Test Data, Test 6, LOC 9

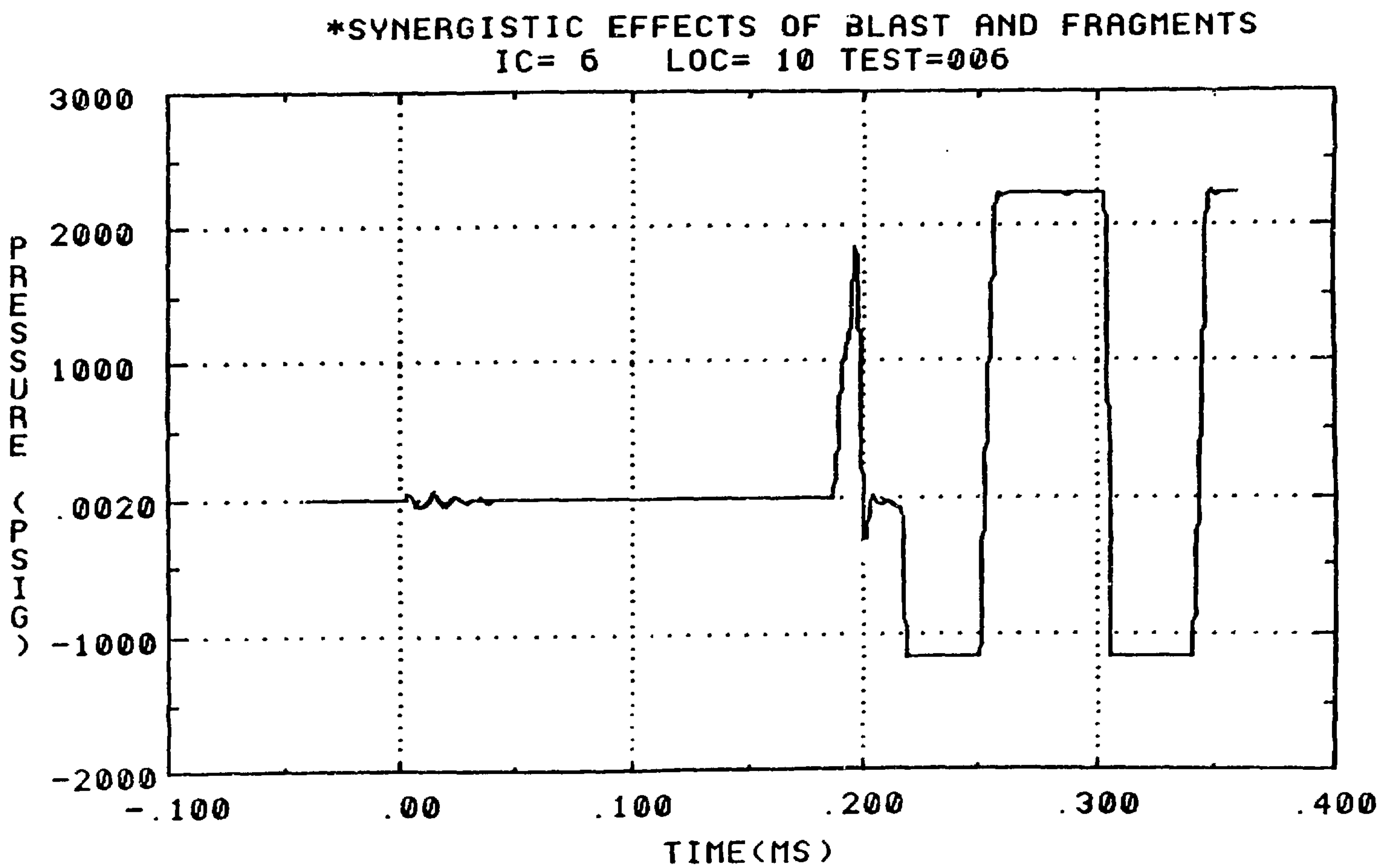


Figure B-8. Loads Test Data, Test 6, LOC 10

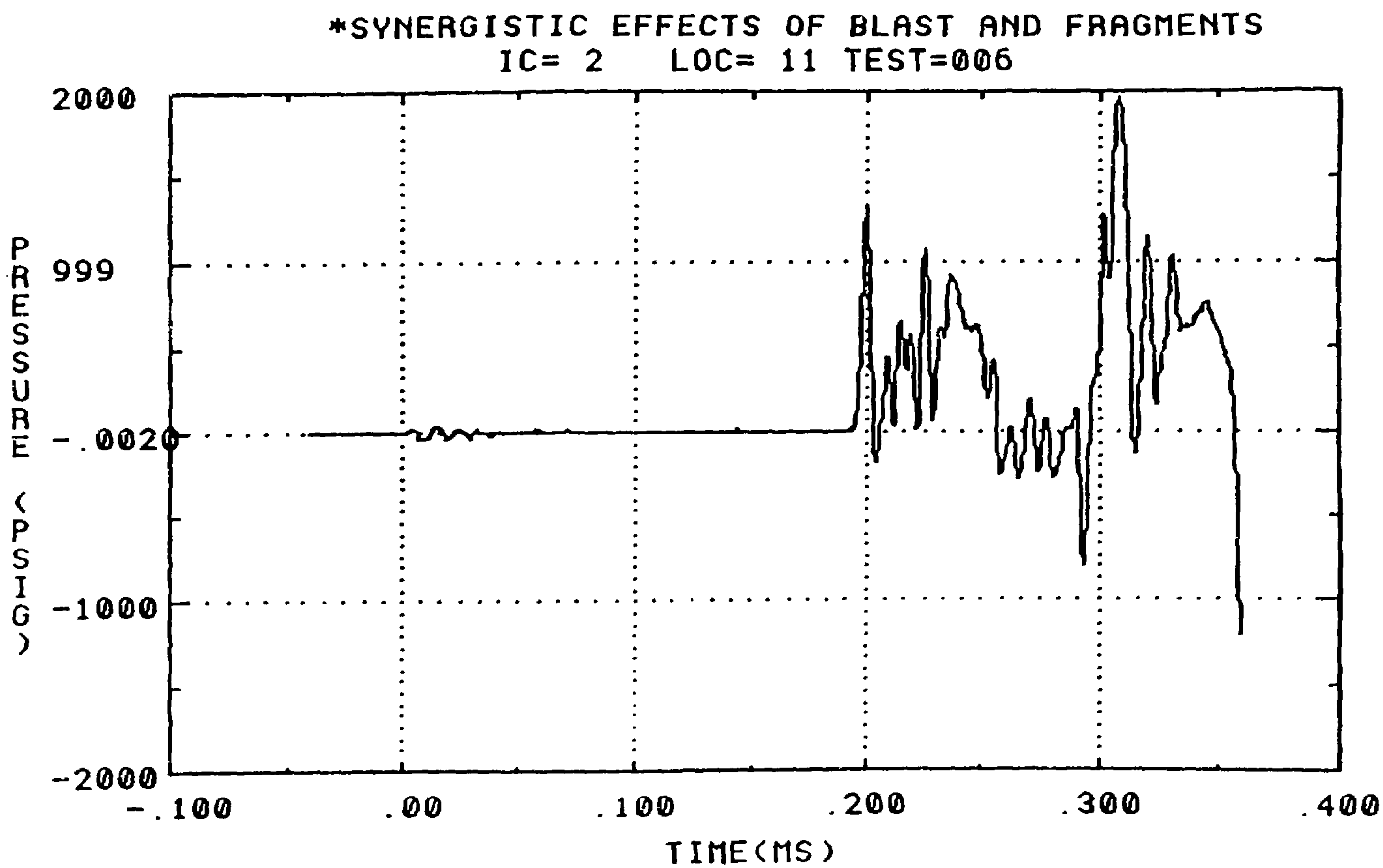


Figure B-9. Loads Test Data, Test 6, LOC 11

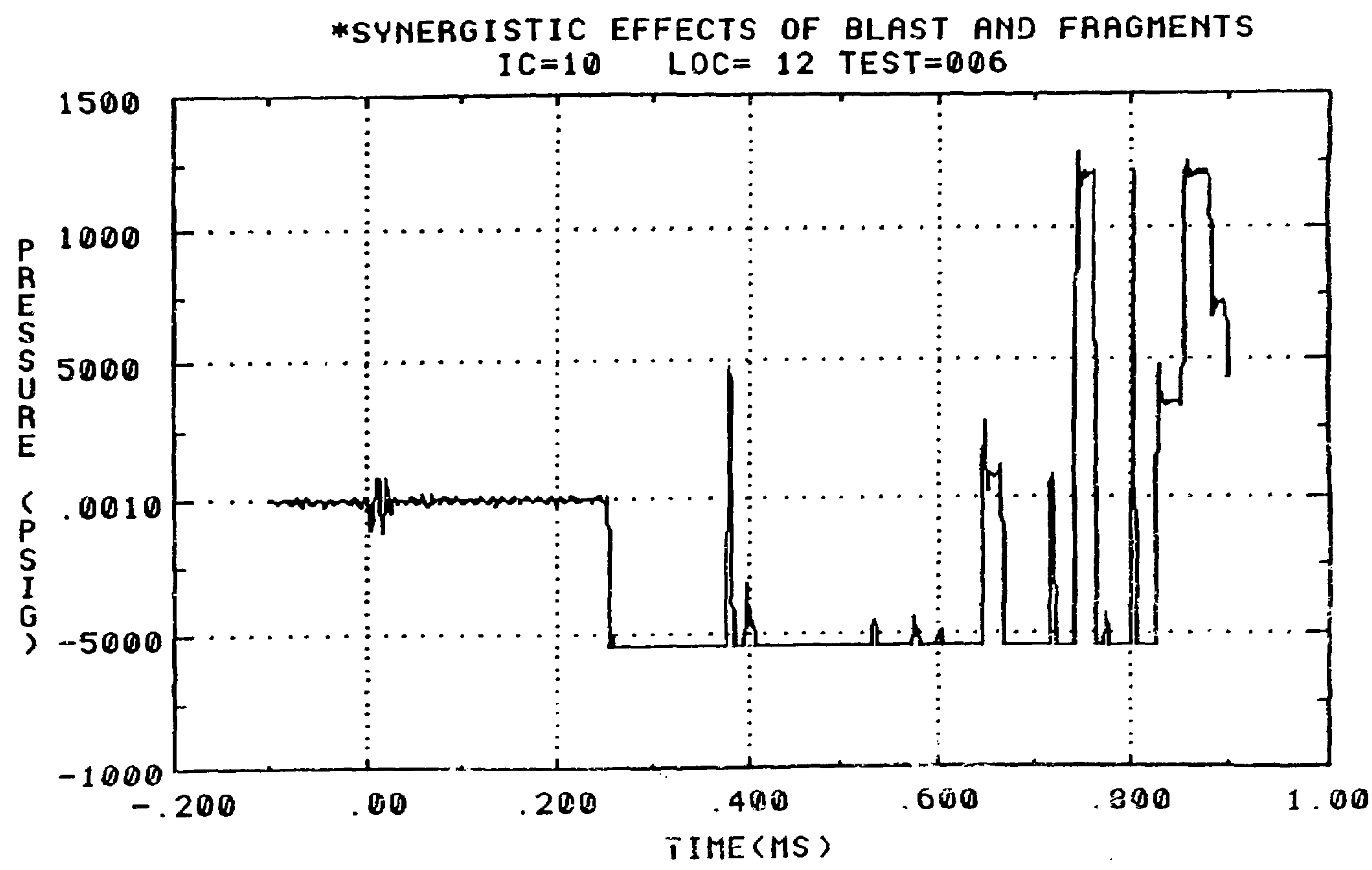


Figure B-10. Loads Test Data, Test 6, LOC 12

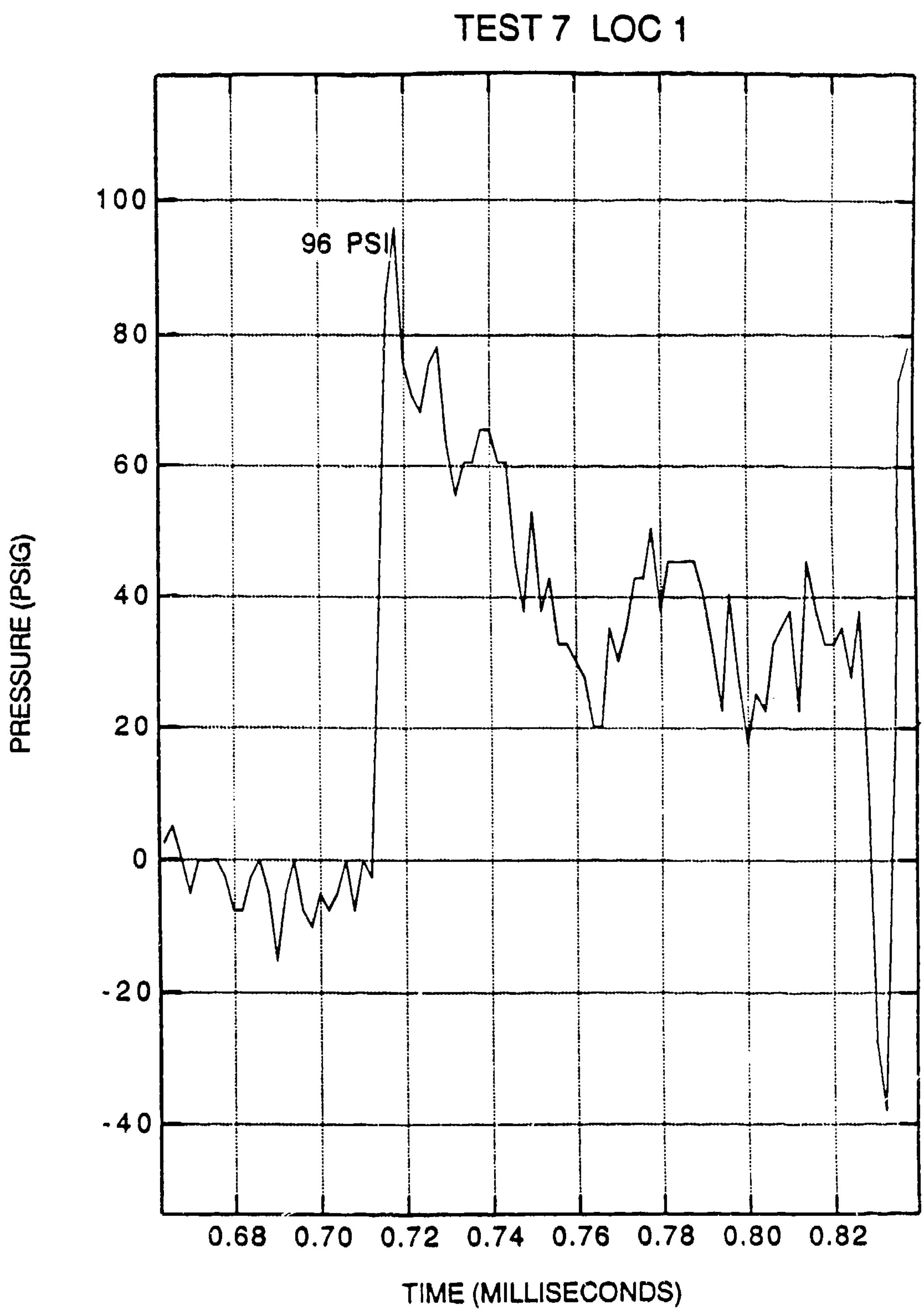


Figure B-11. Loads Test Data, Test 7, LOC 1

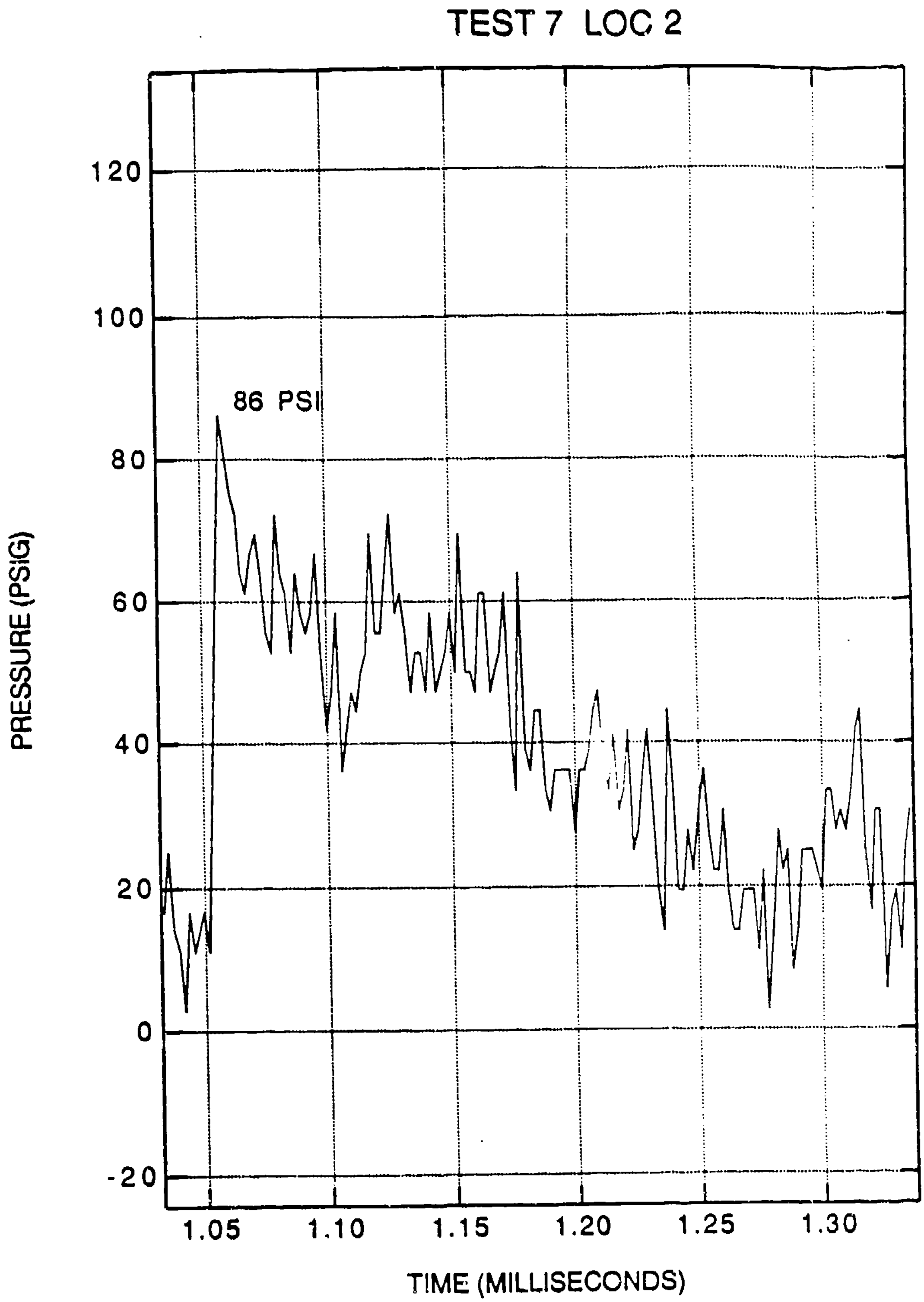


Figure B-12. Loads Test Data, Test 7, LOC 2

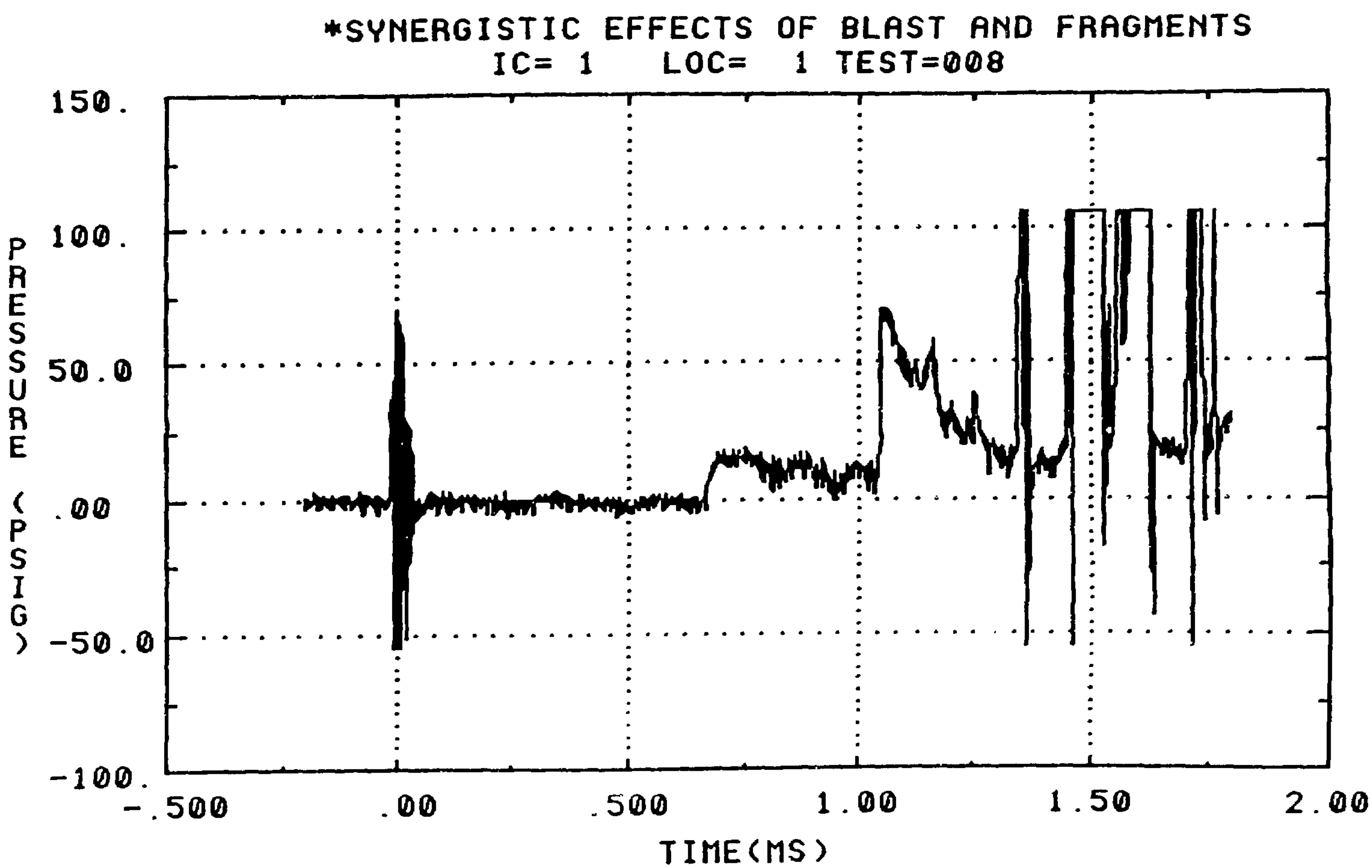


Figure B-13. Loads Test Data, Test 8, LOC 1

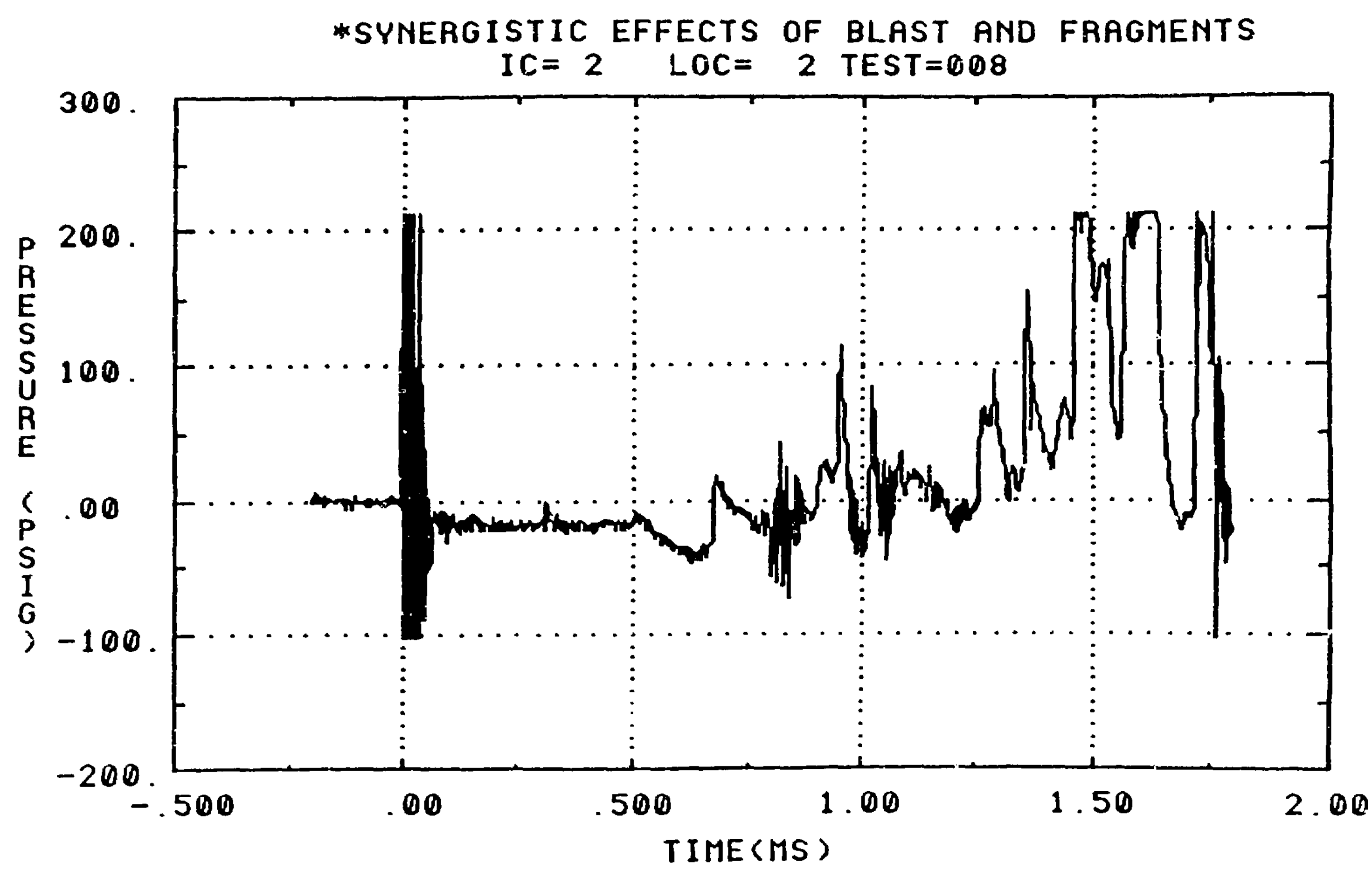


Figure B-14. Loads Test Data, Test 8, LOC 2

(The reverse side of this page is blank.)

APPENDIX C

Test Data from Panel Tests

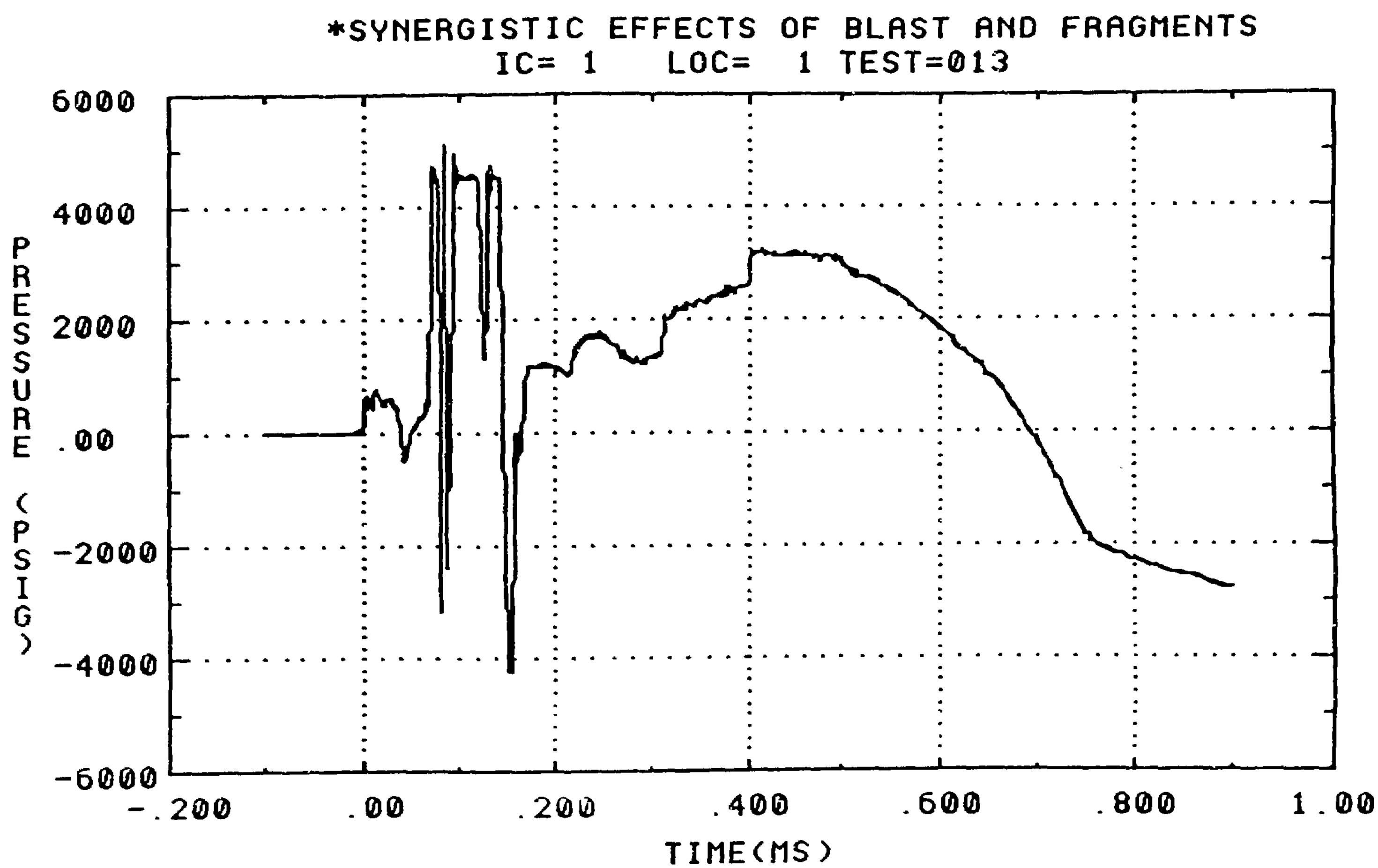


Figure C-1. Loads Test Data, Test 13, LOC 1

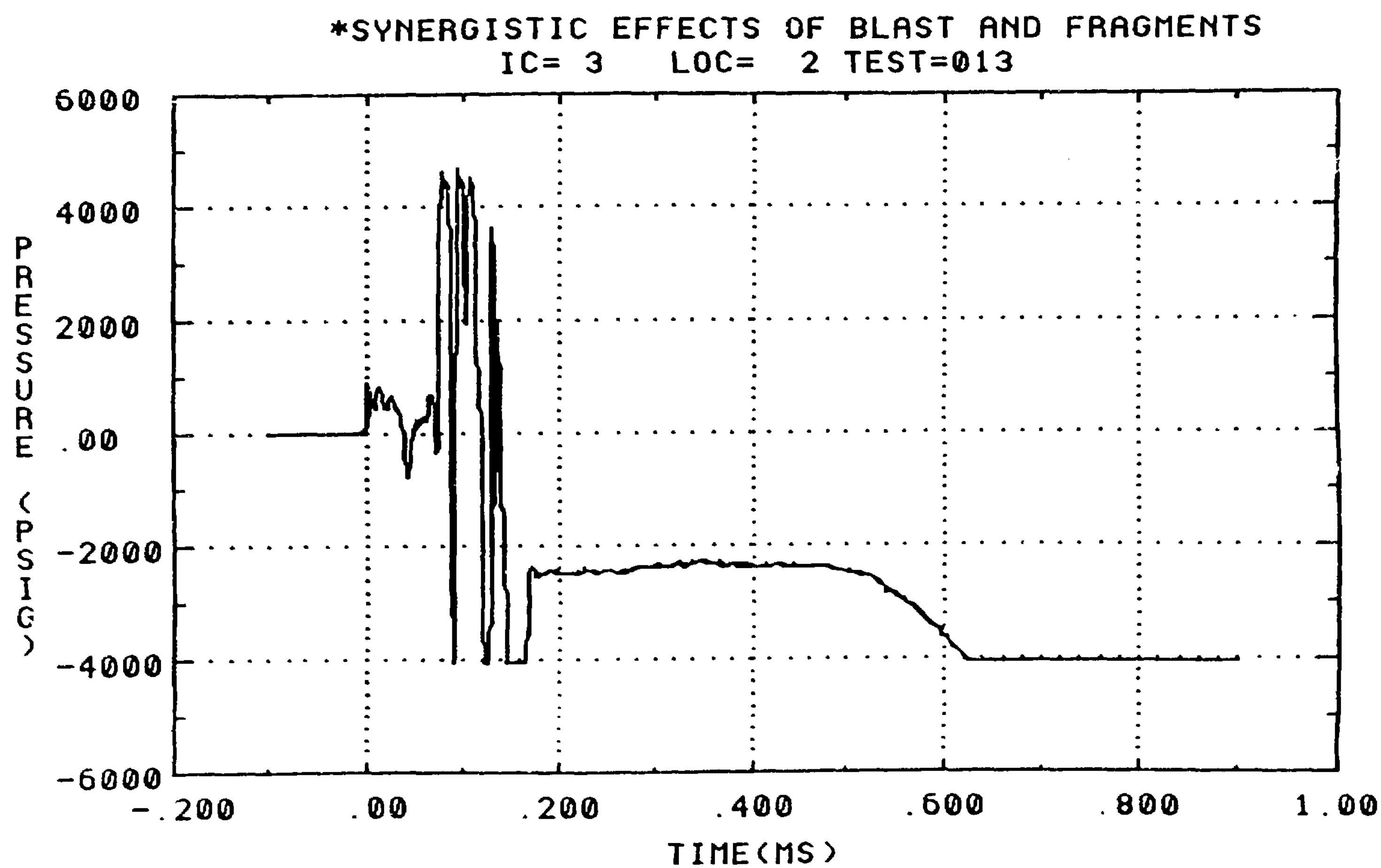


Figure C-2. Loads Test Data, Test 13, LOC 2

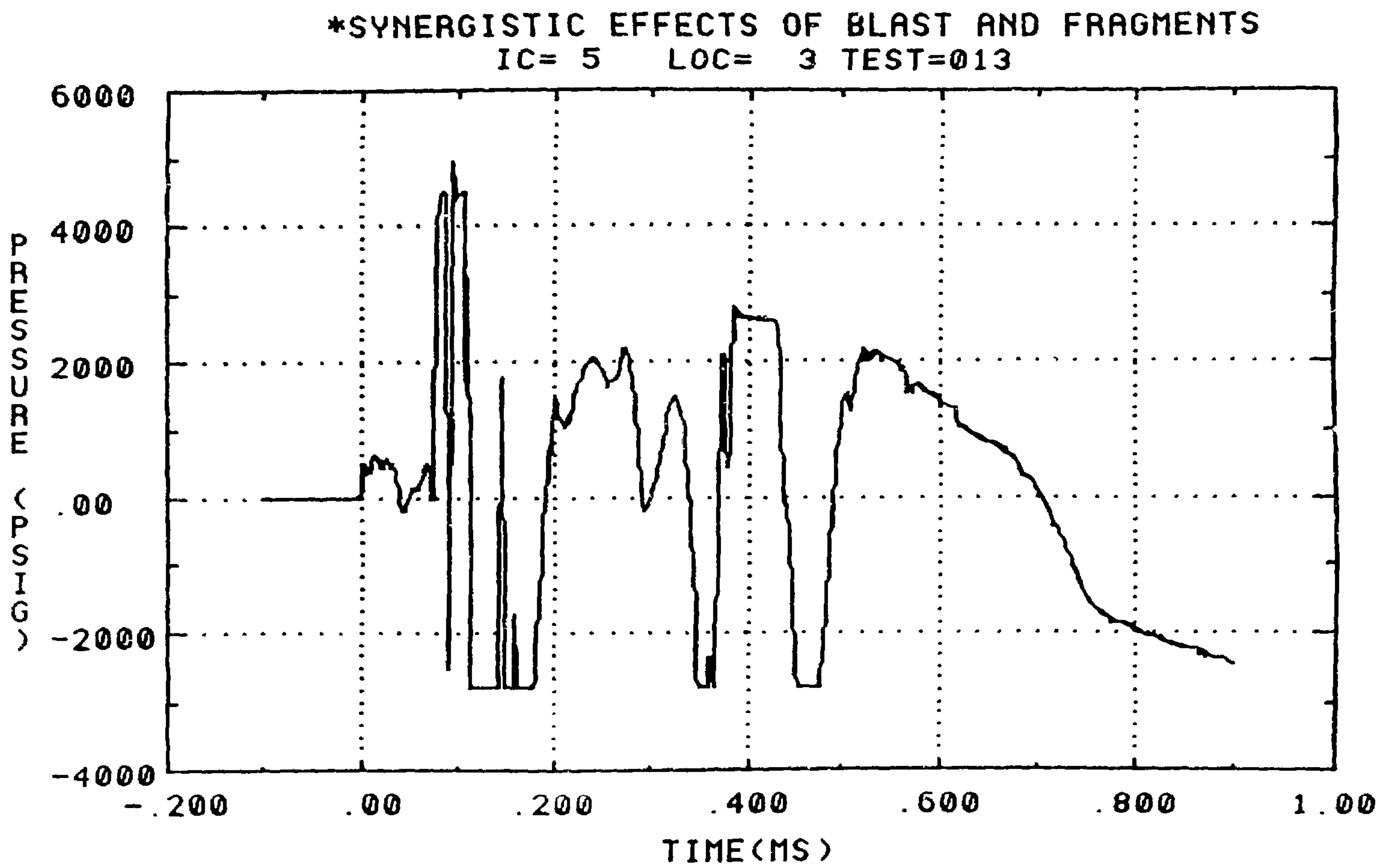


Figure C-3. Loads Test Data, Test 13, LOC 3

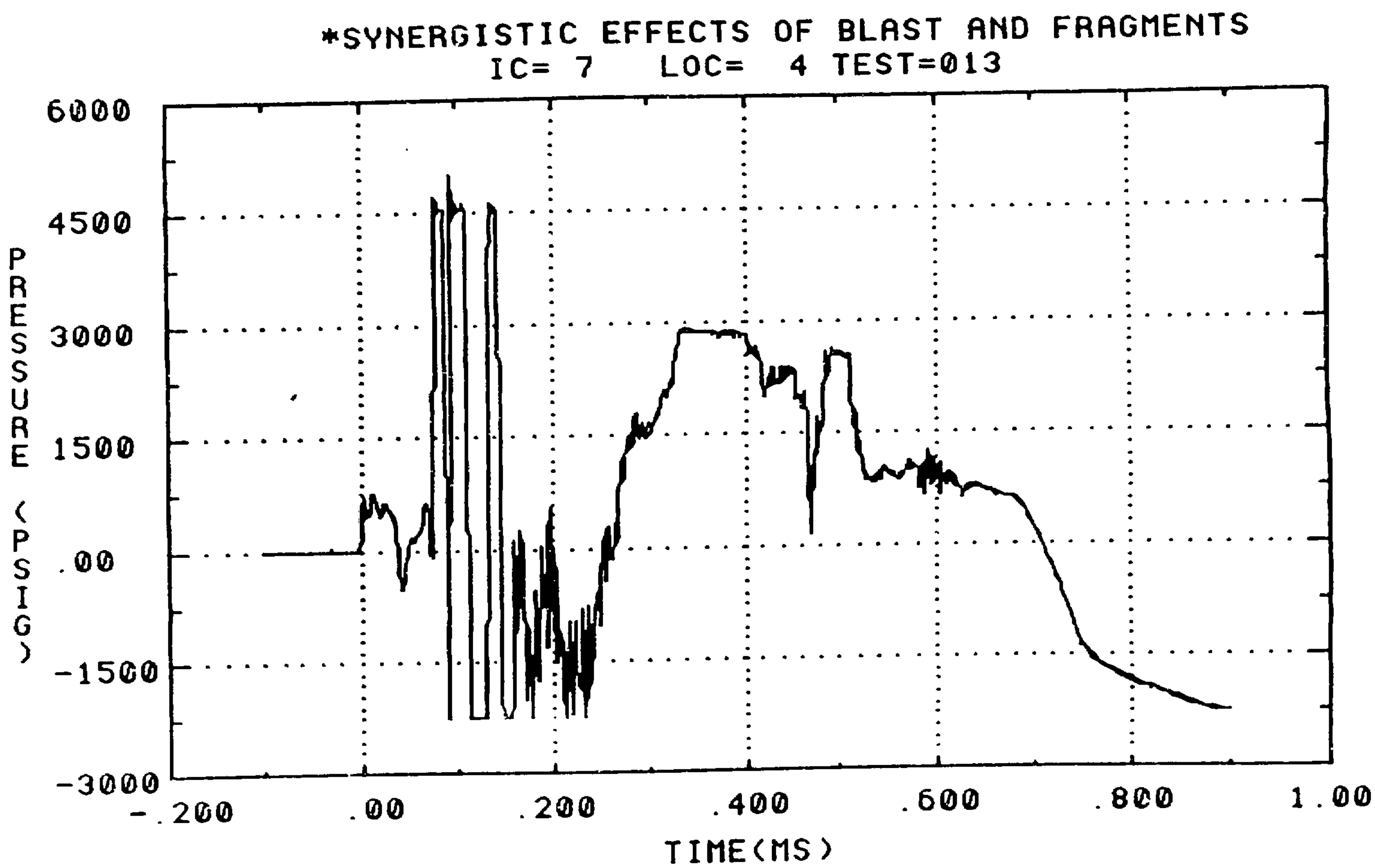


Figure C-4. Loads Test Data, Test 13, LOC 4

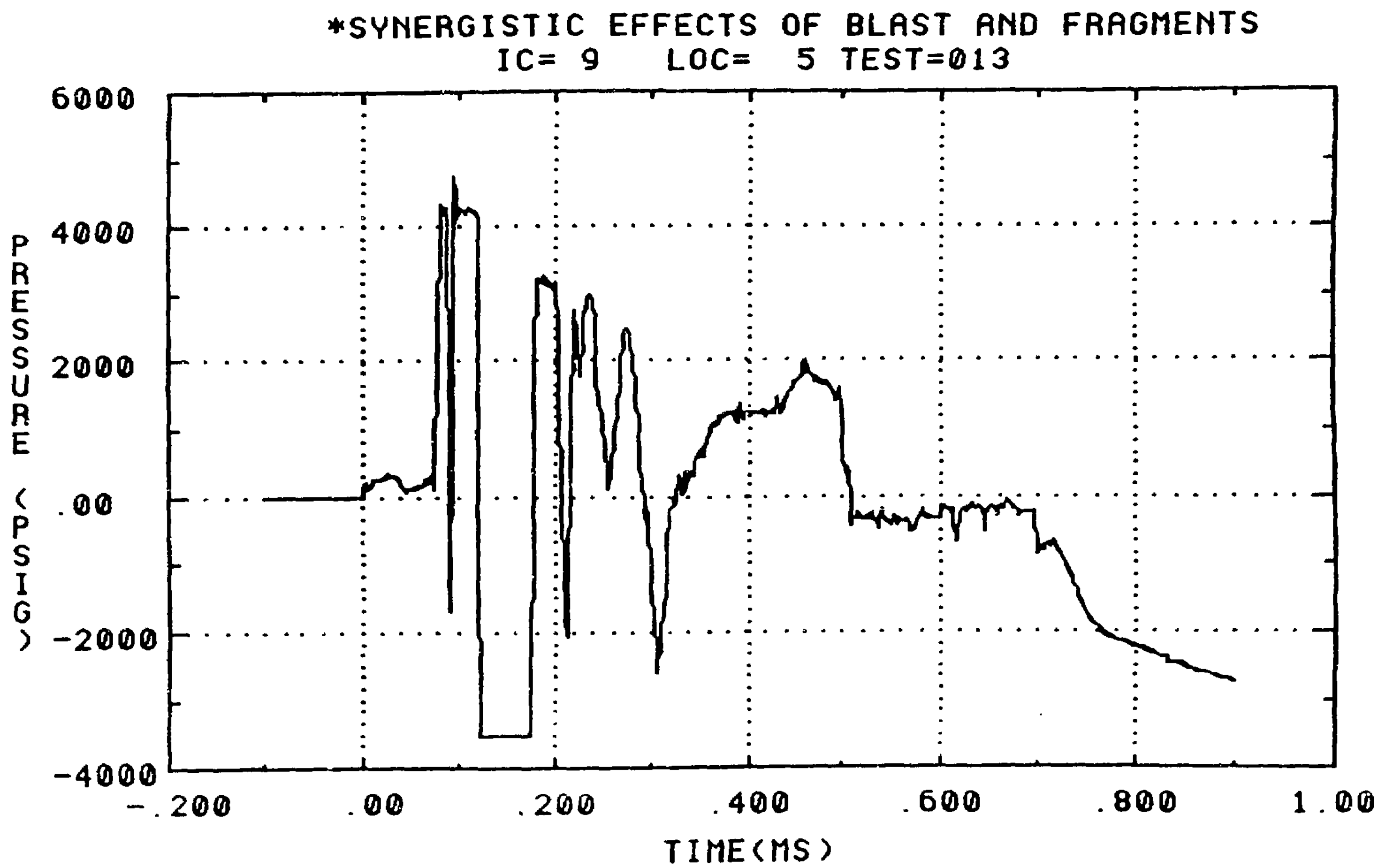


Figure C-5. Loads Test Data, Test 13, LOC 5

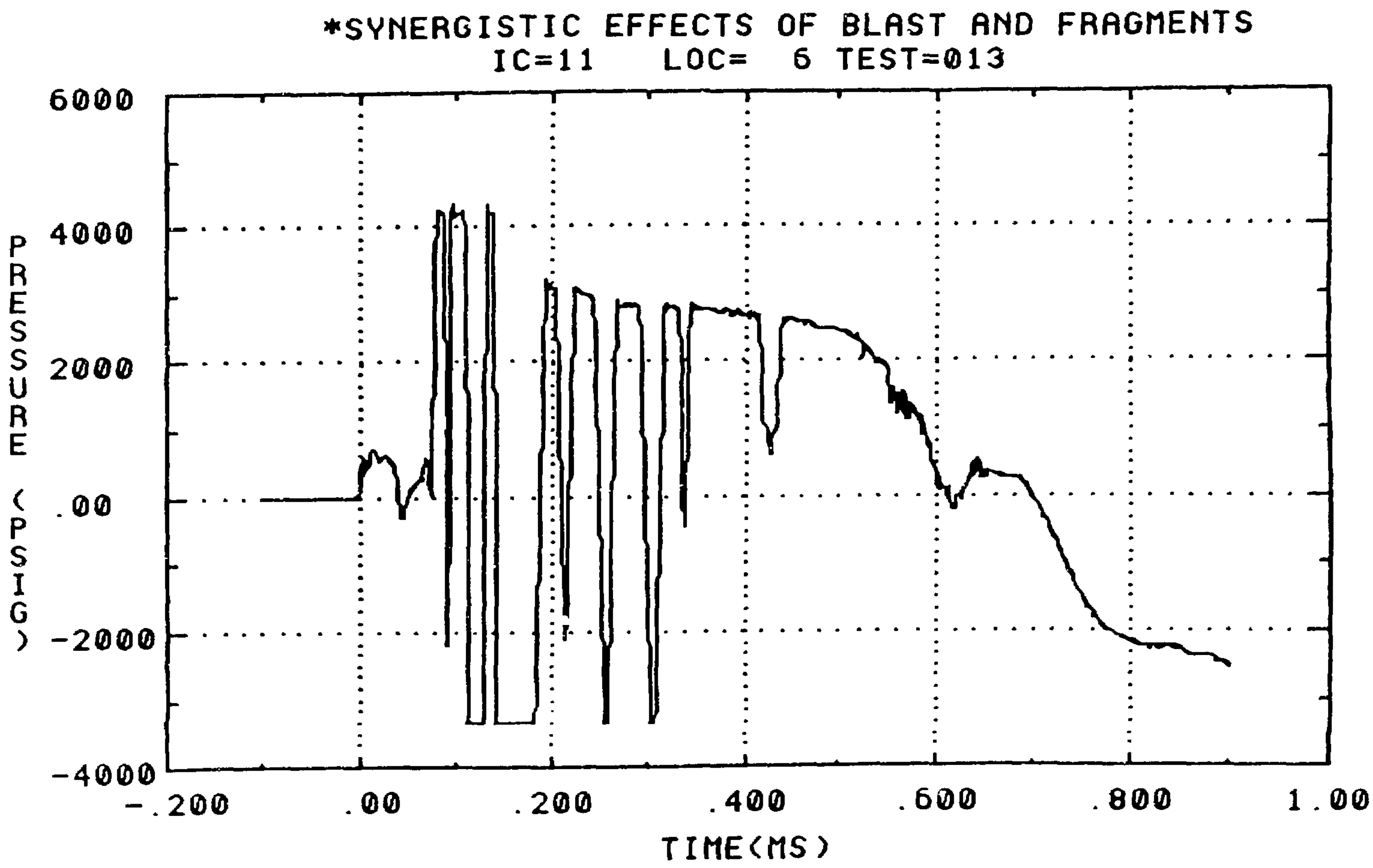


Figure C-6. Loads Test Data, Test 13, LOC 6

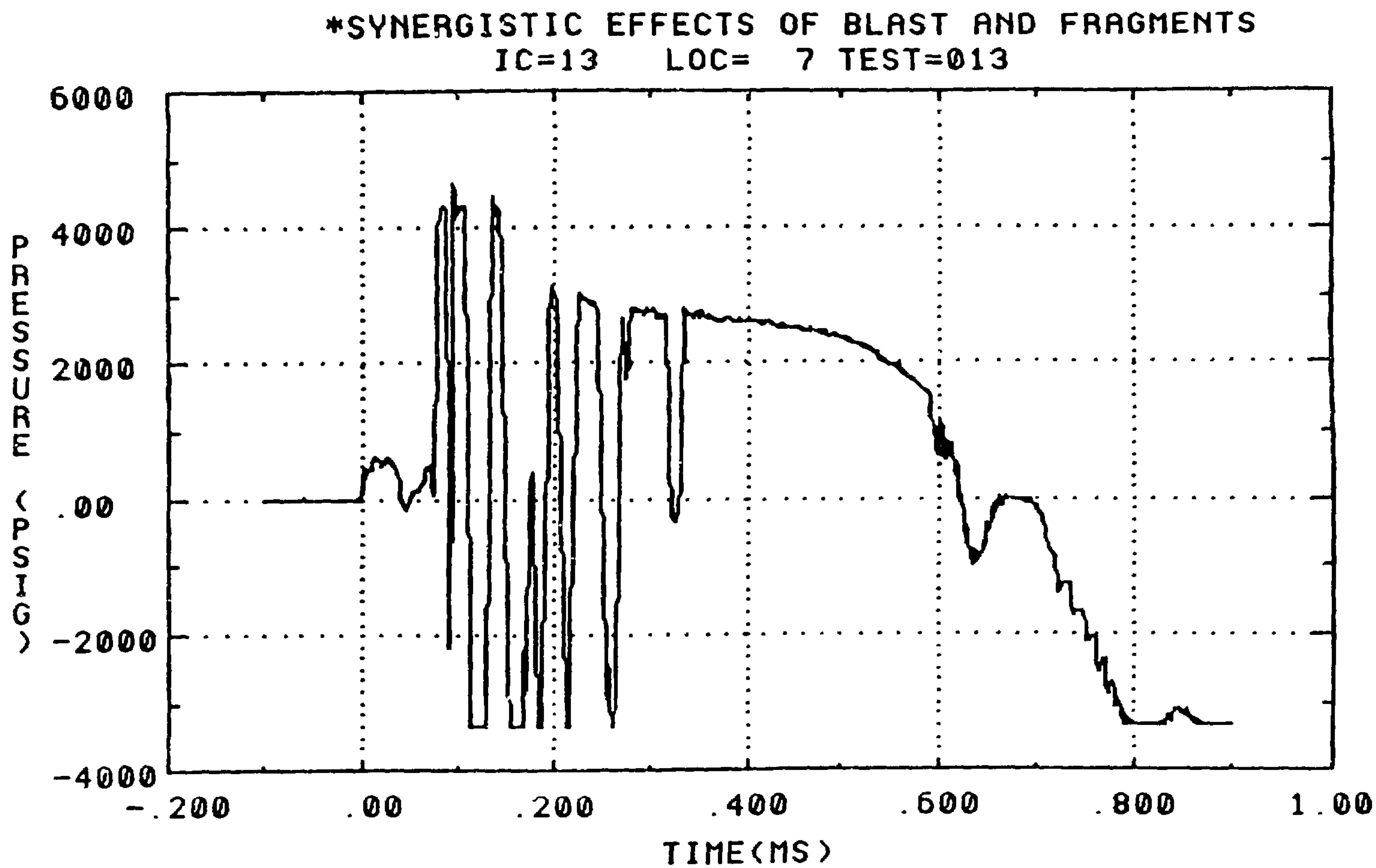


Figure C-7. Loads Test Data, Test 13, LOC 7

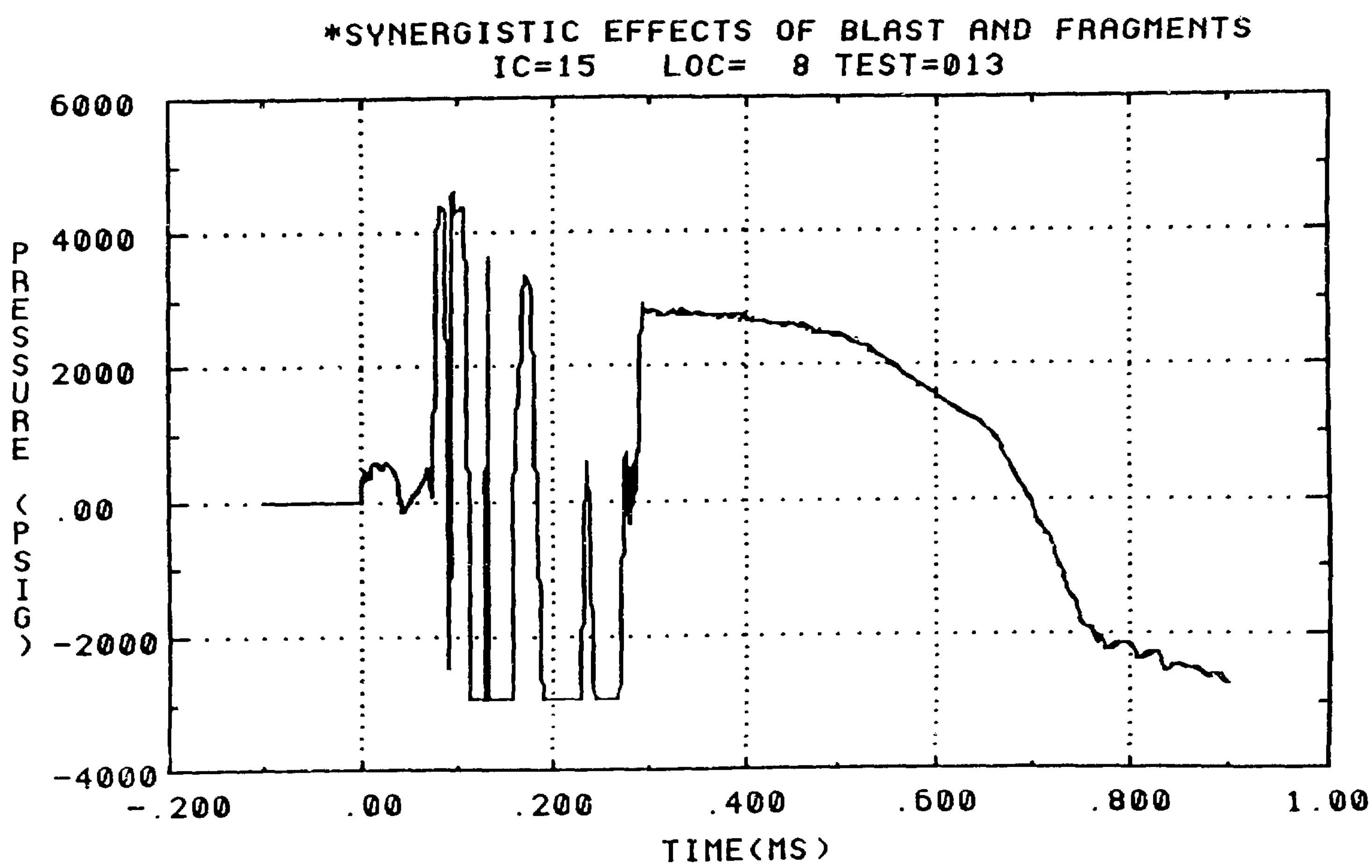


Figure C-8. Loads Test Data, Test 13, LOC 8

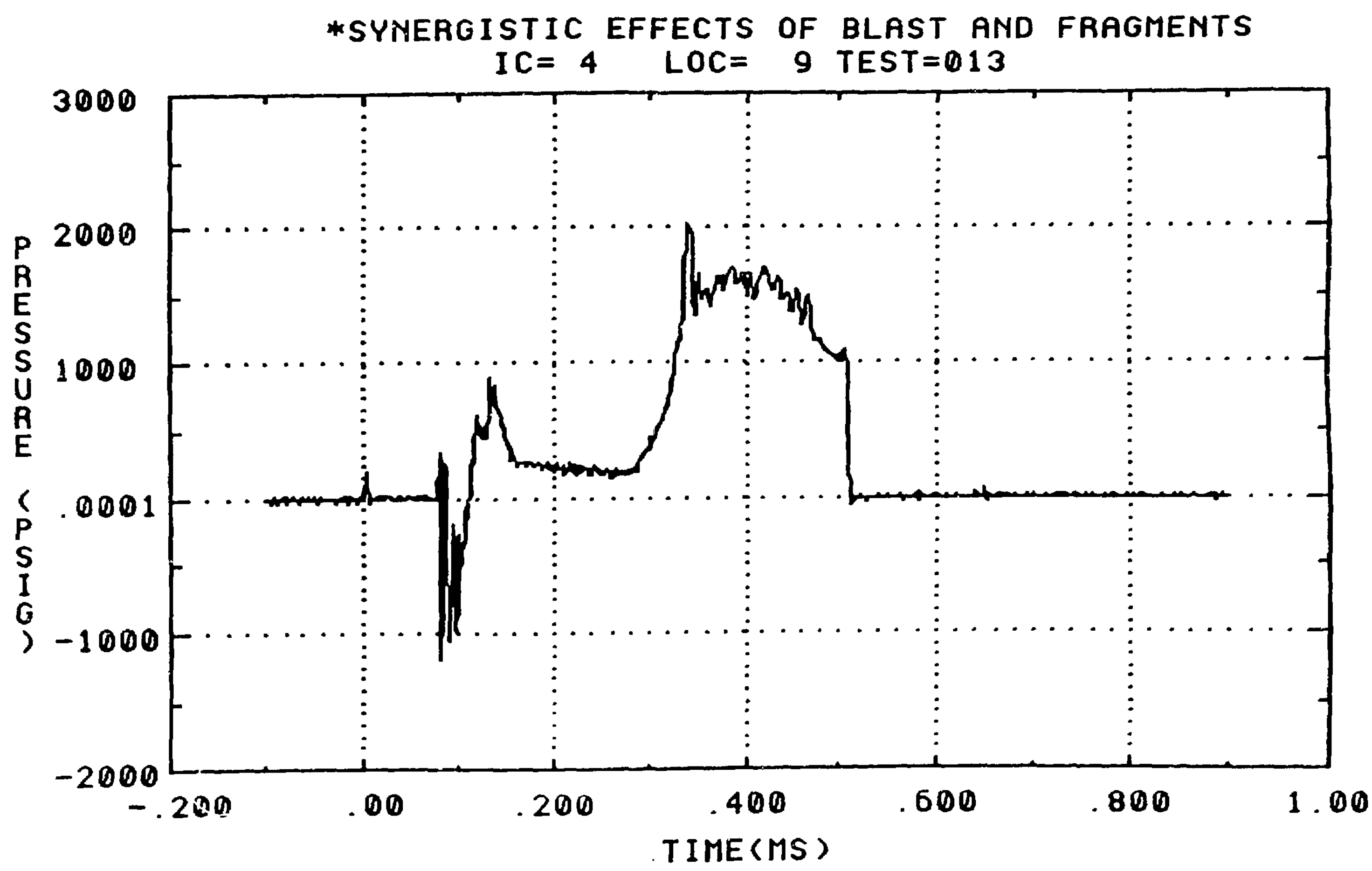


Figure C-9. Loads Test Data, Test 13, LOC 9

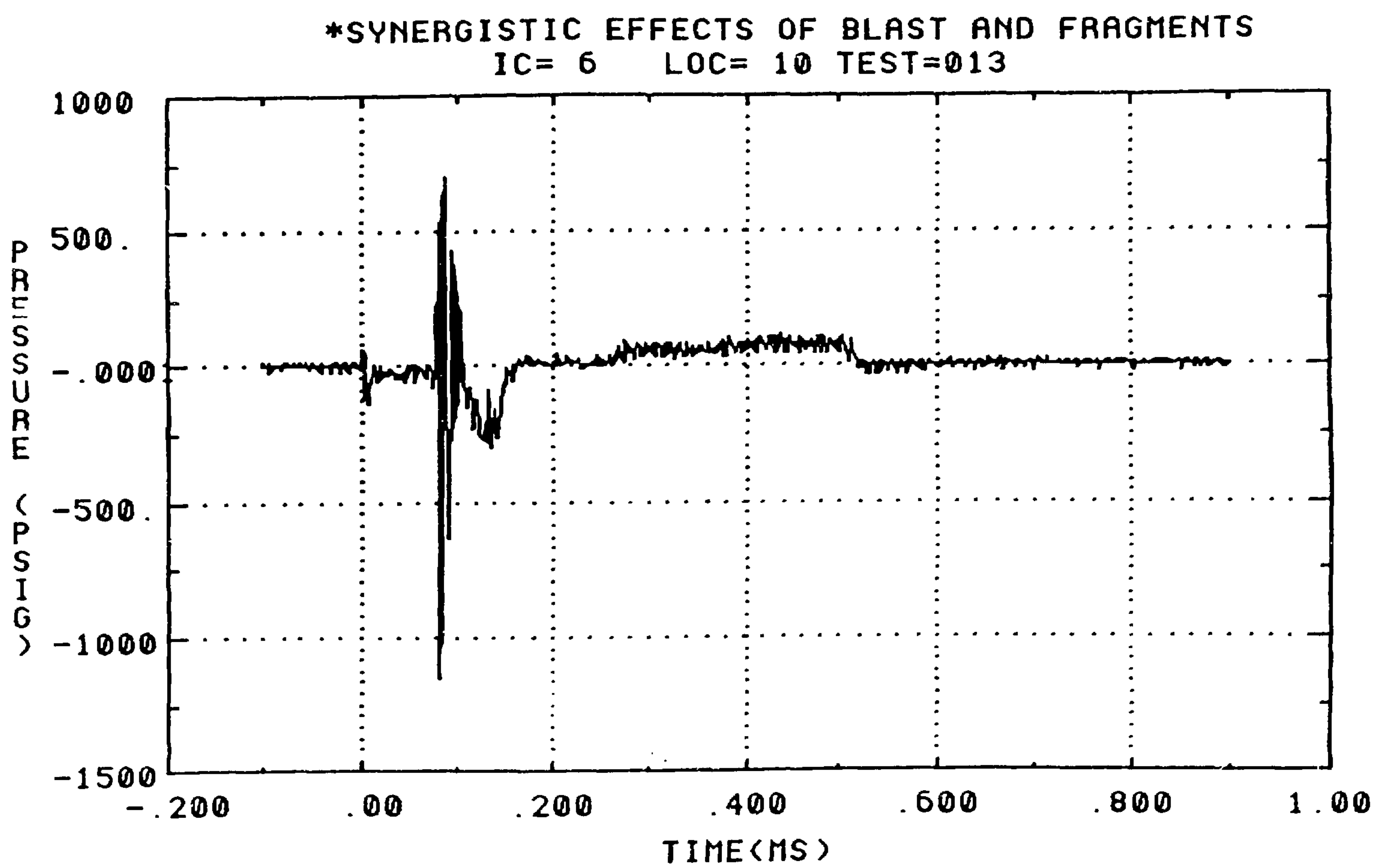


Figure C-10. Loads Test Data, Test 13, LOC 10

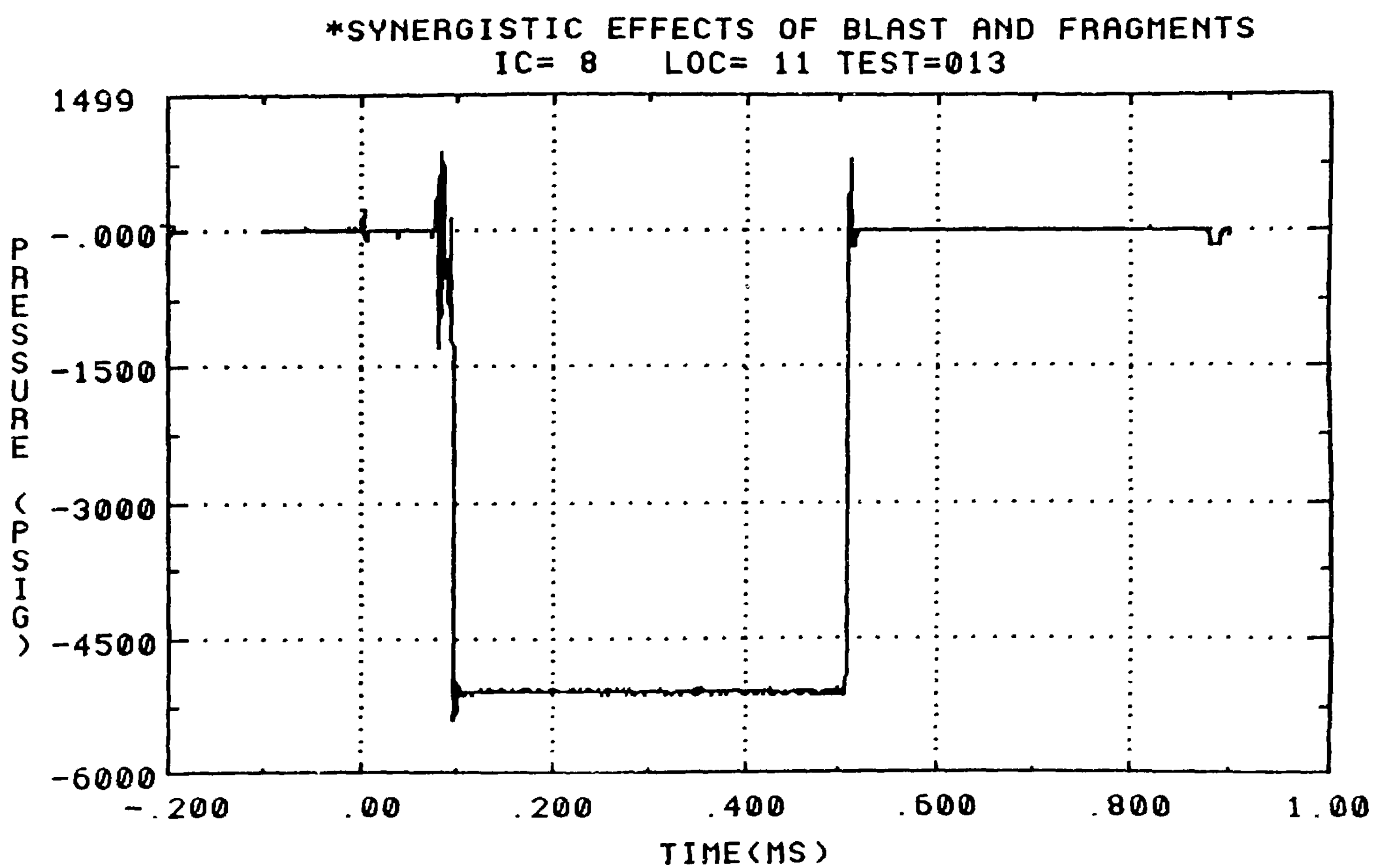


Figure C-11. Loads Test Data, Test 13, LOC 11

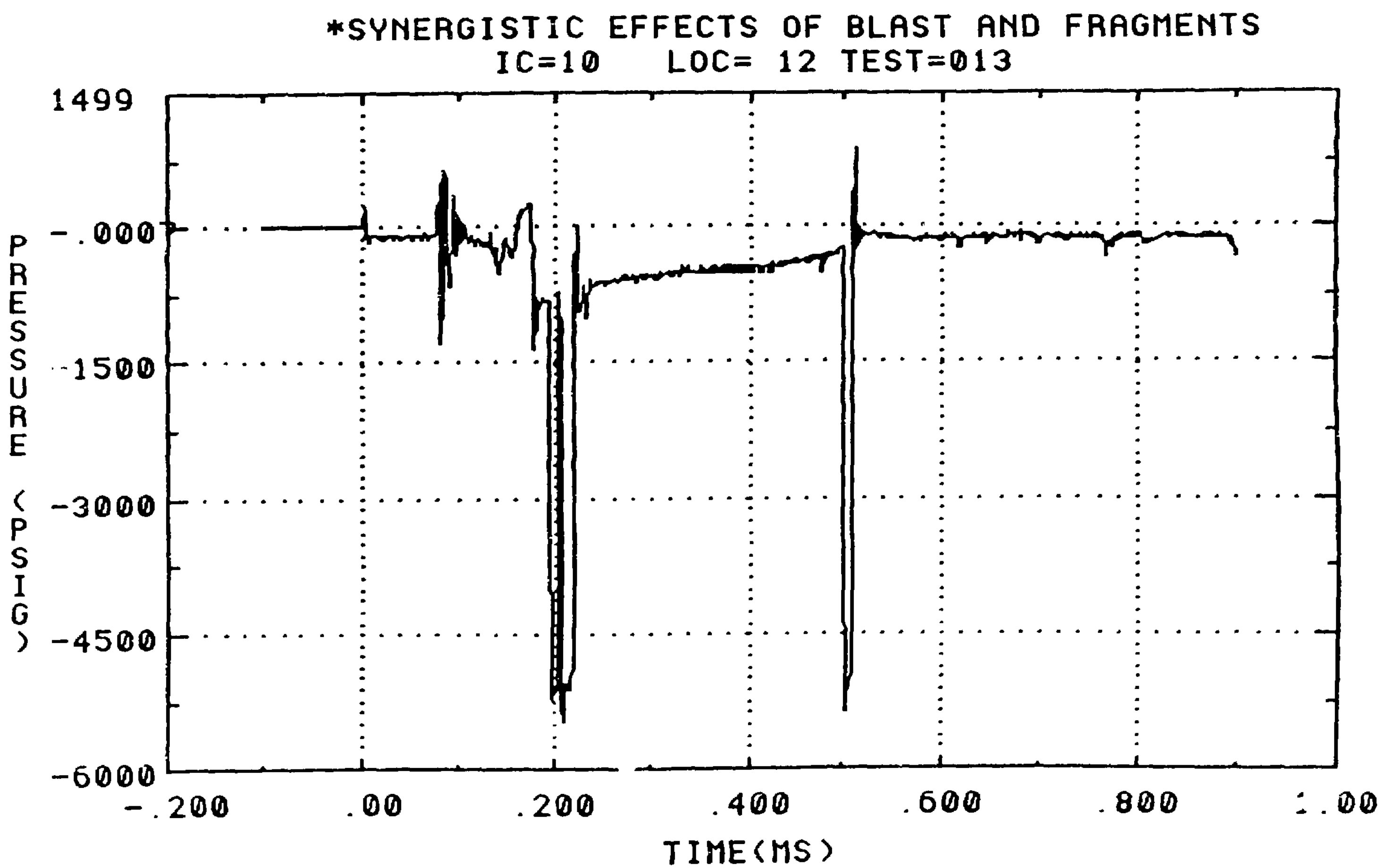


Figure C-12. Loads Test Data, Test 13, LOC 12

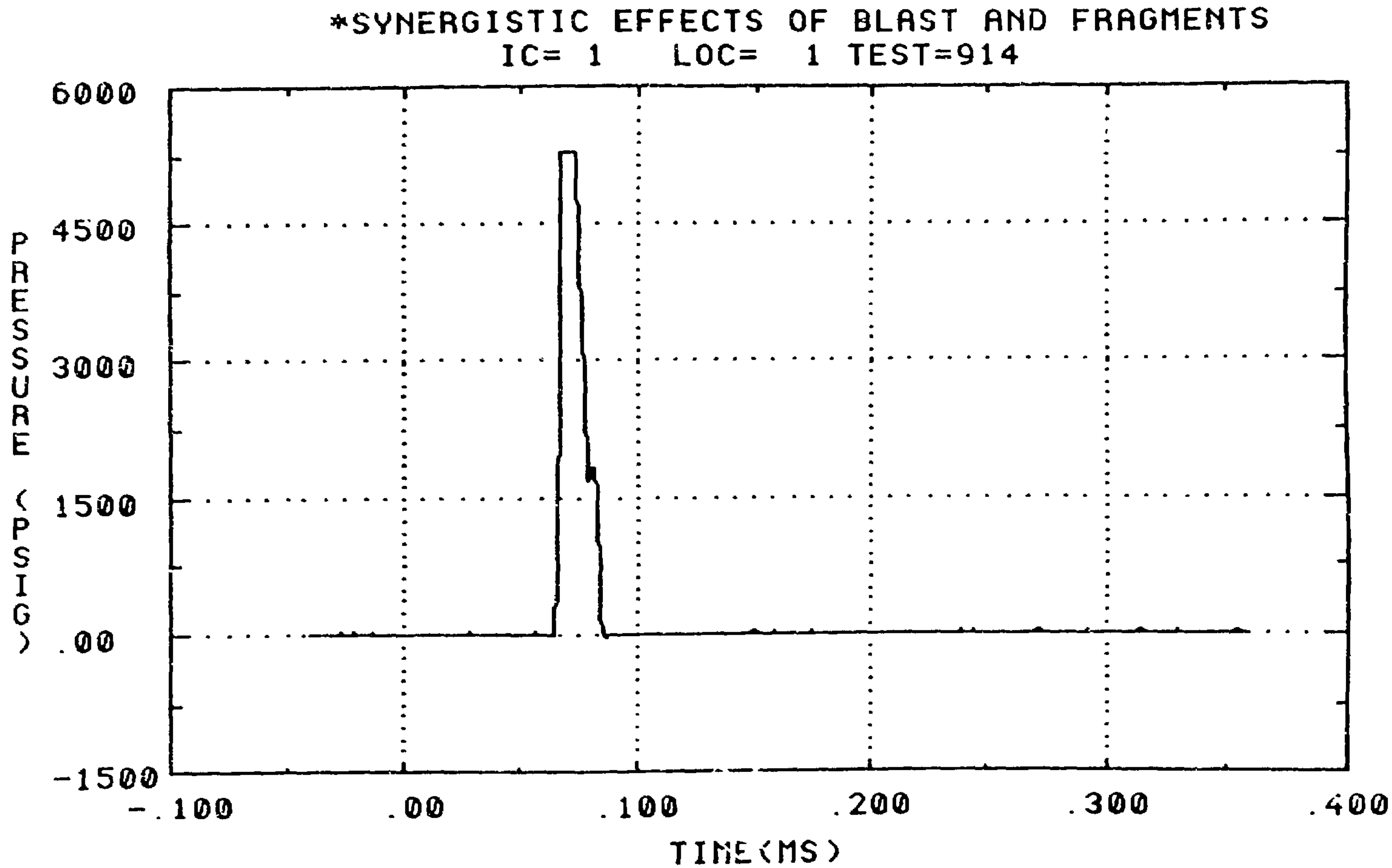


Figure C-13. Loads Test Data, Test 914, LOC 1

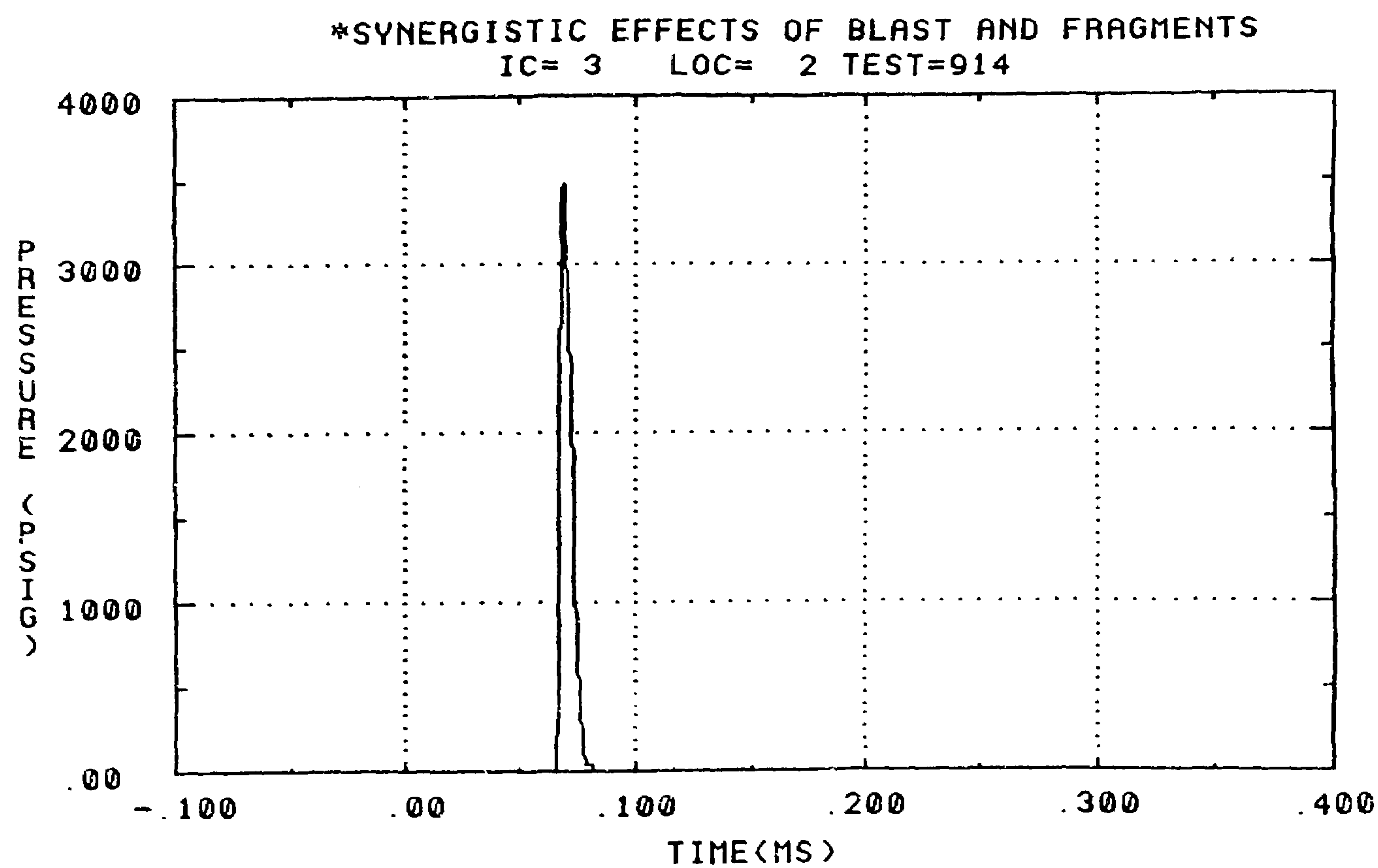


Figure C-14. Loads Test Data, Test 914, LOC 2

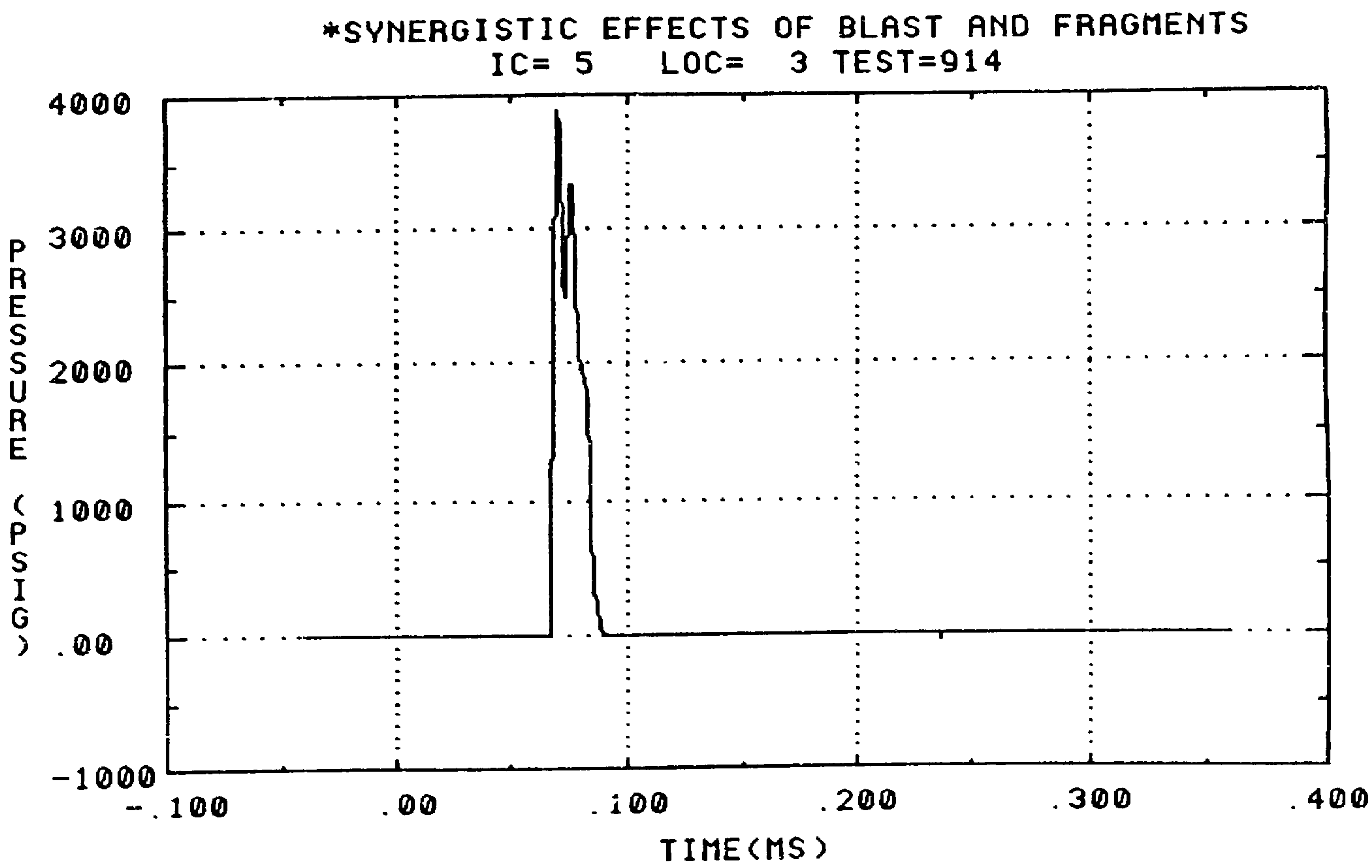


Figure C-15. Loads Test Data, Test 914, LOC 3

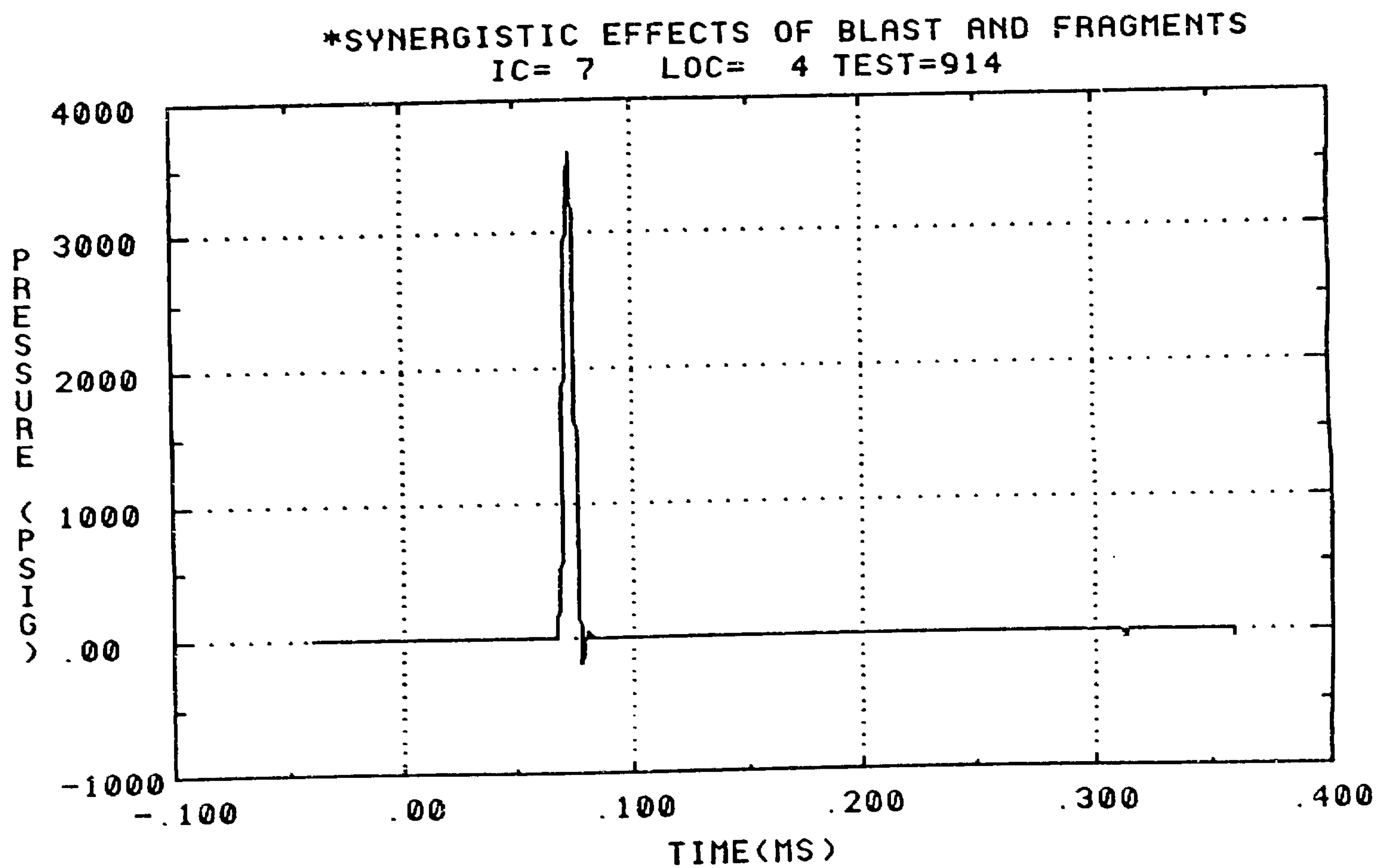


Figure C-16. Loads Test Data, Test 914, LOC 4

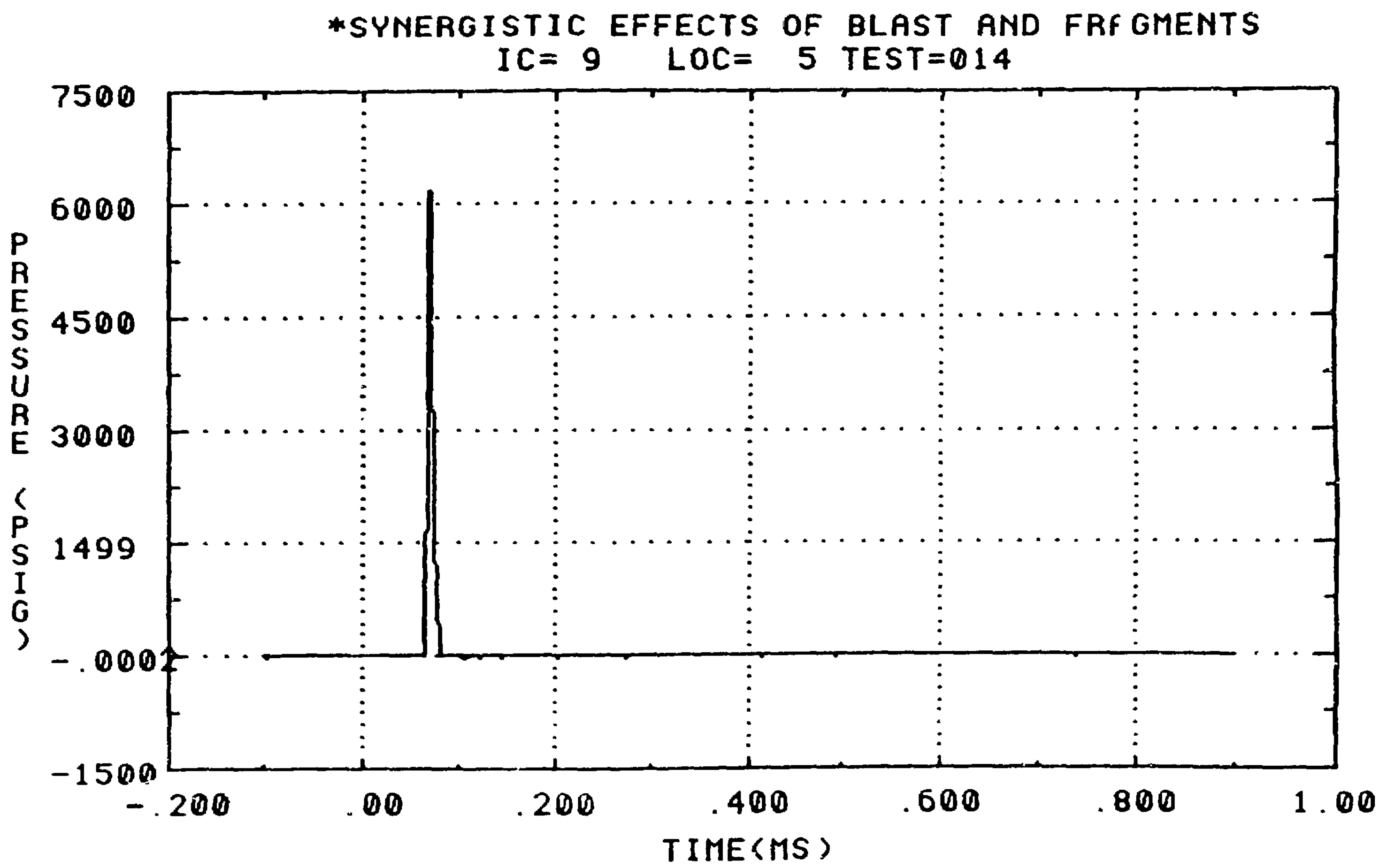


Figure C-17. Loads Test Data, Test 014, LOC 5

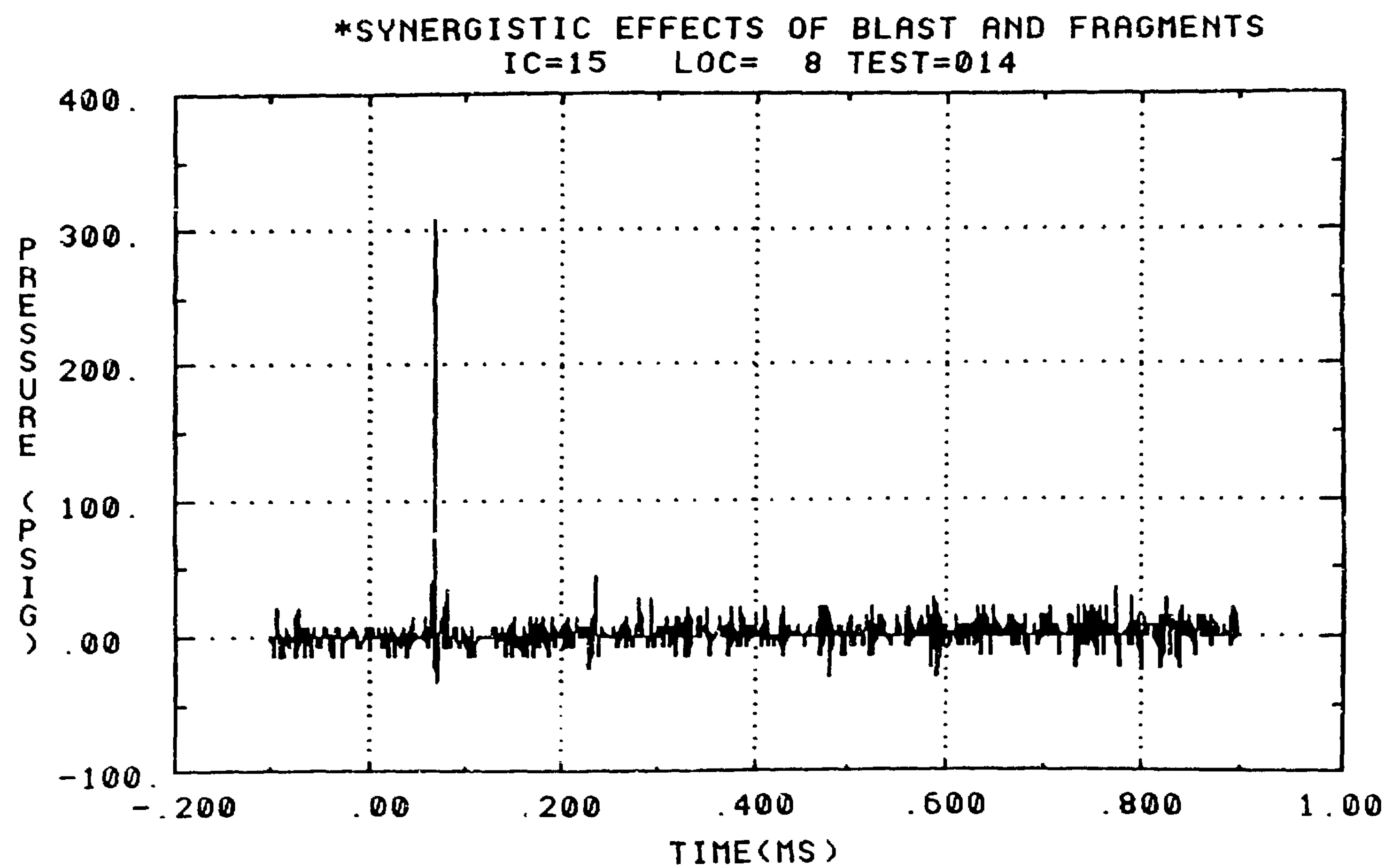


Figure C-18. Loads Test Data, Test 014, LOC 8

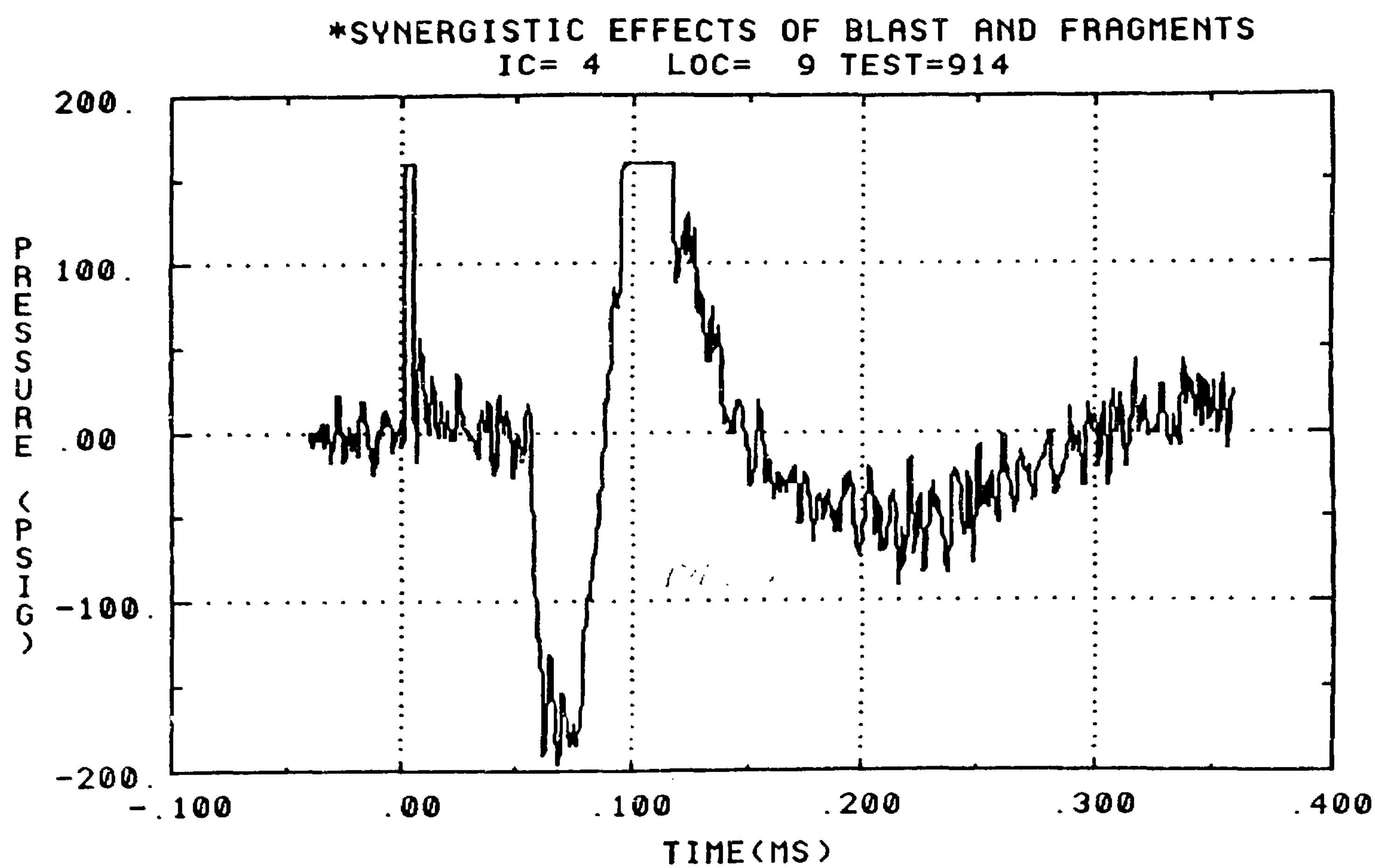


Figure C-19. Loads Test Data, Test 914, LOC 9

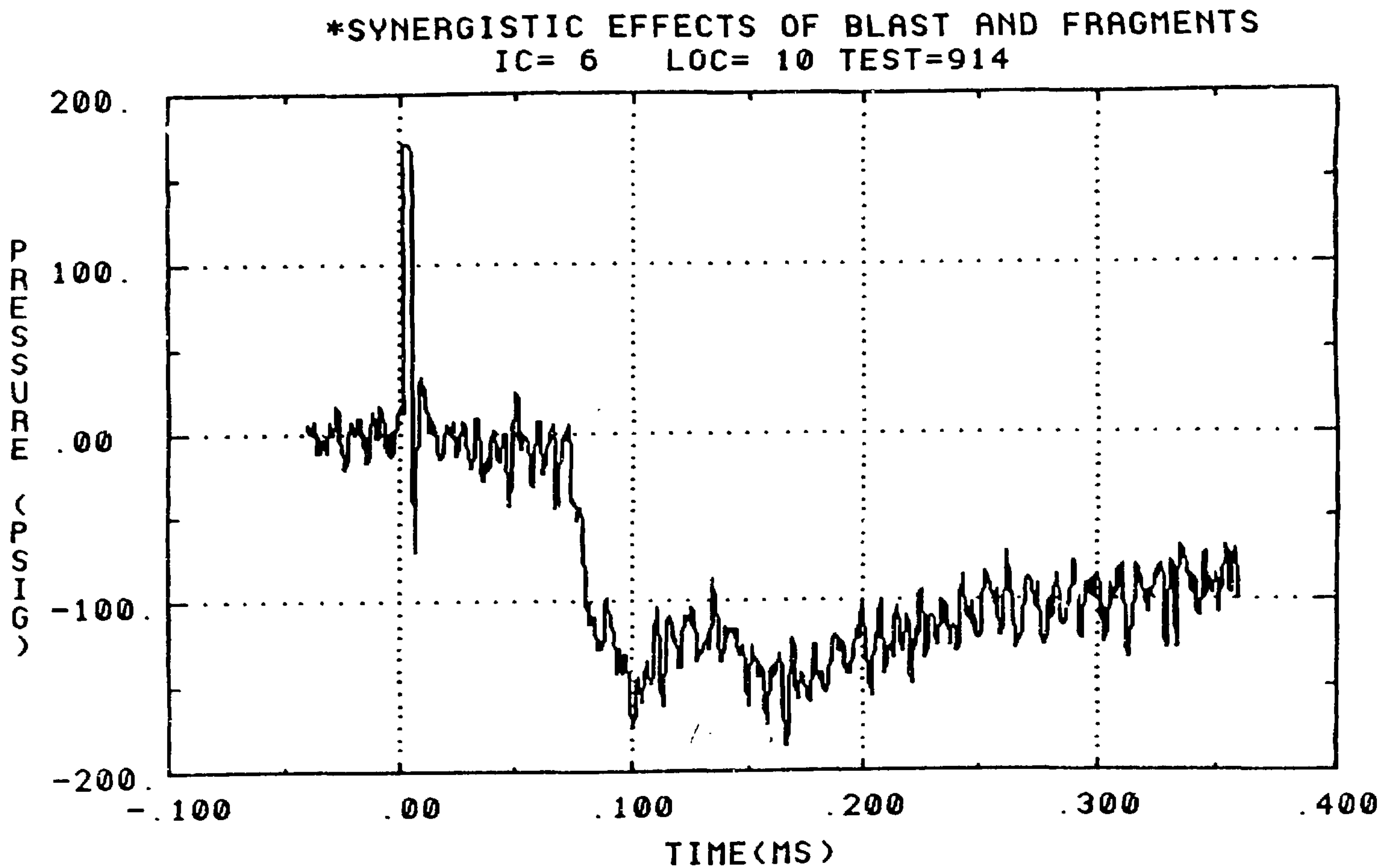


Figure C-20. Loads Test Data, Test 914, LOC 10

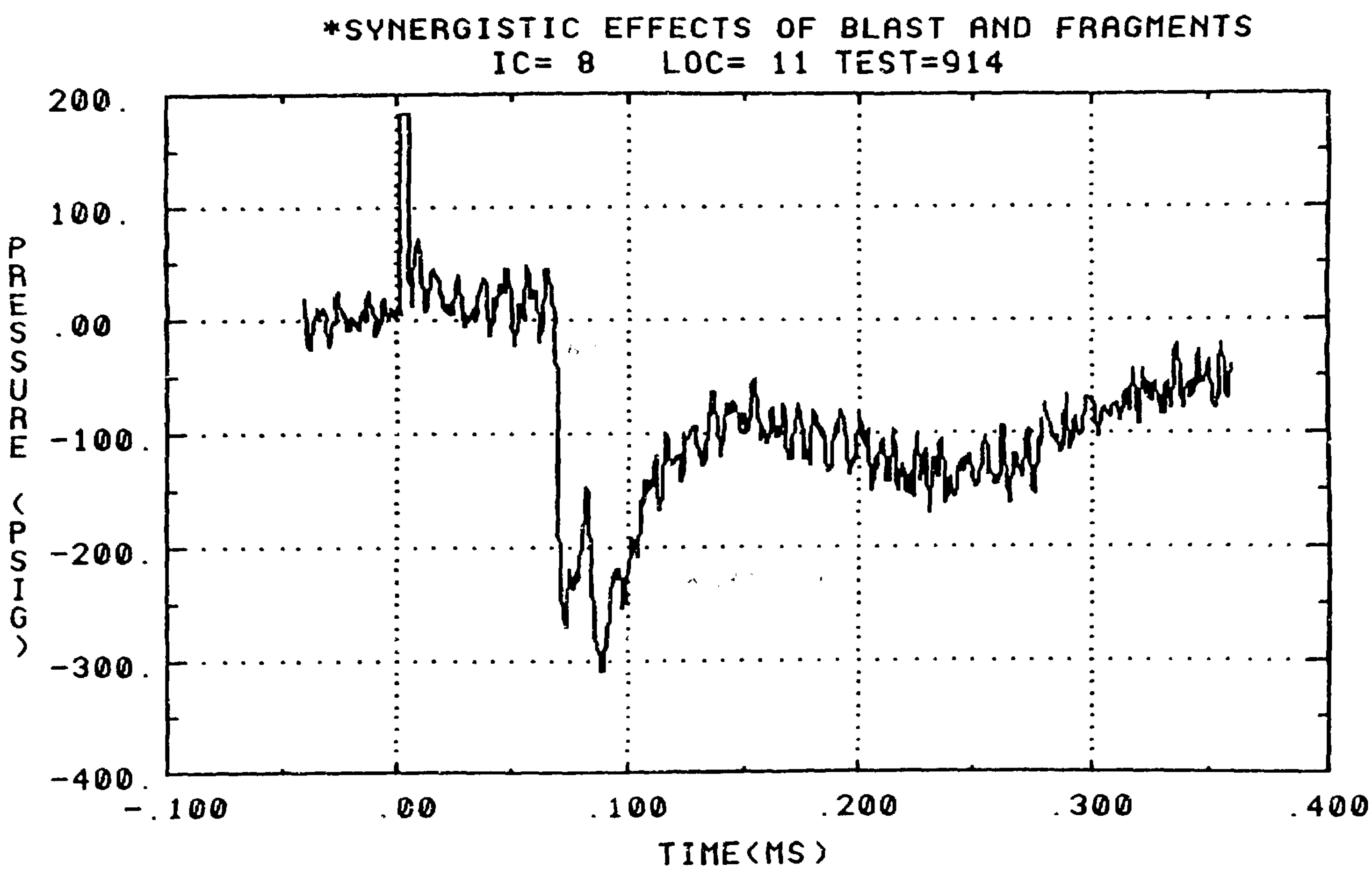


Figure C-21. Loads Test Data, Test 914, LOC 11

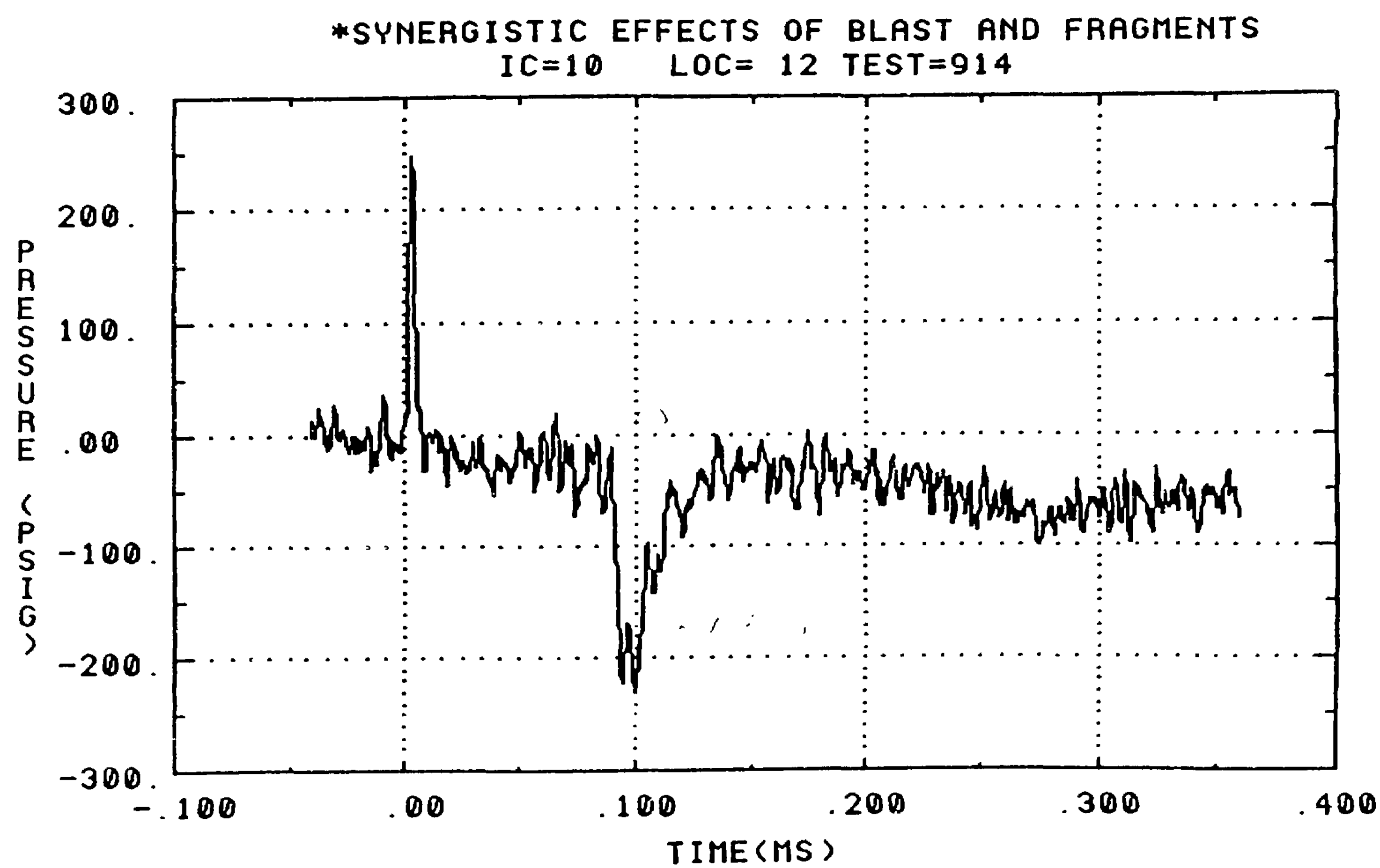


Figure C-22. Loads Test Data, Test 914, LOC 12

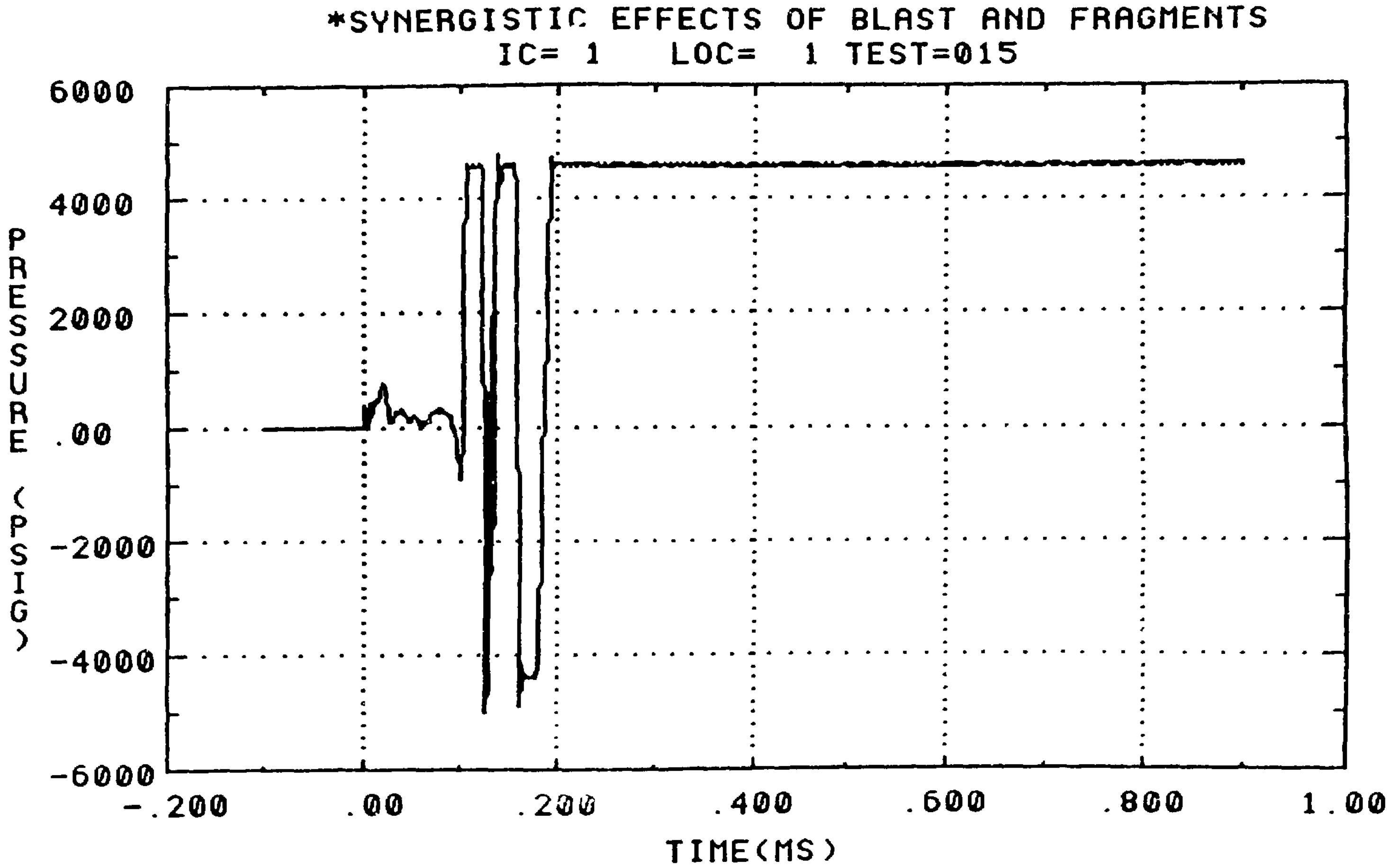


Figure C-23. Loads Test Data, Test 15, LOC 1

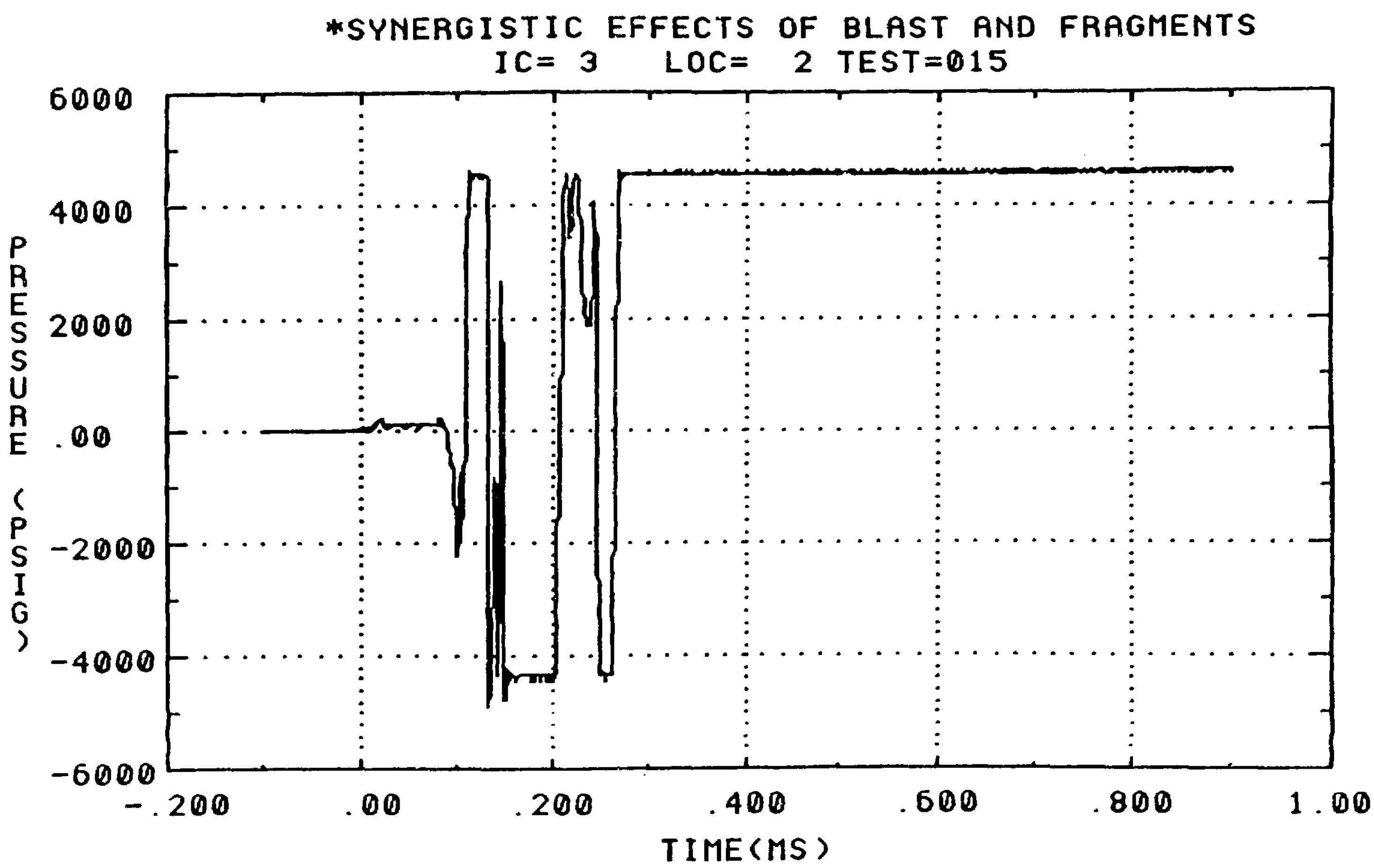


Figure C-24. Loads Test Data, Test 15, LOC 2

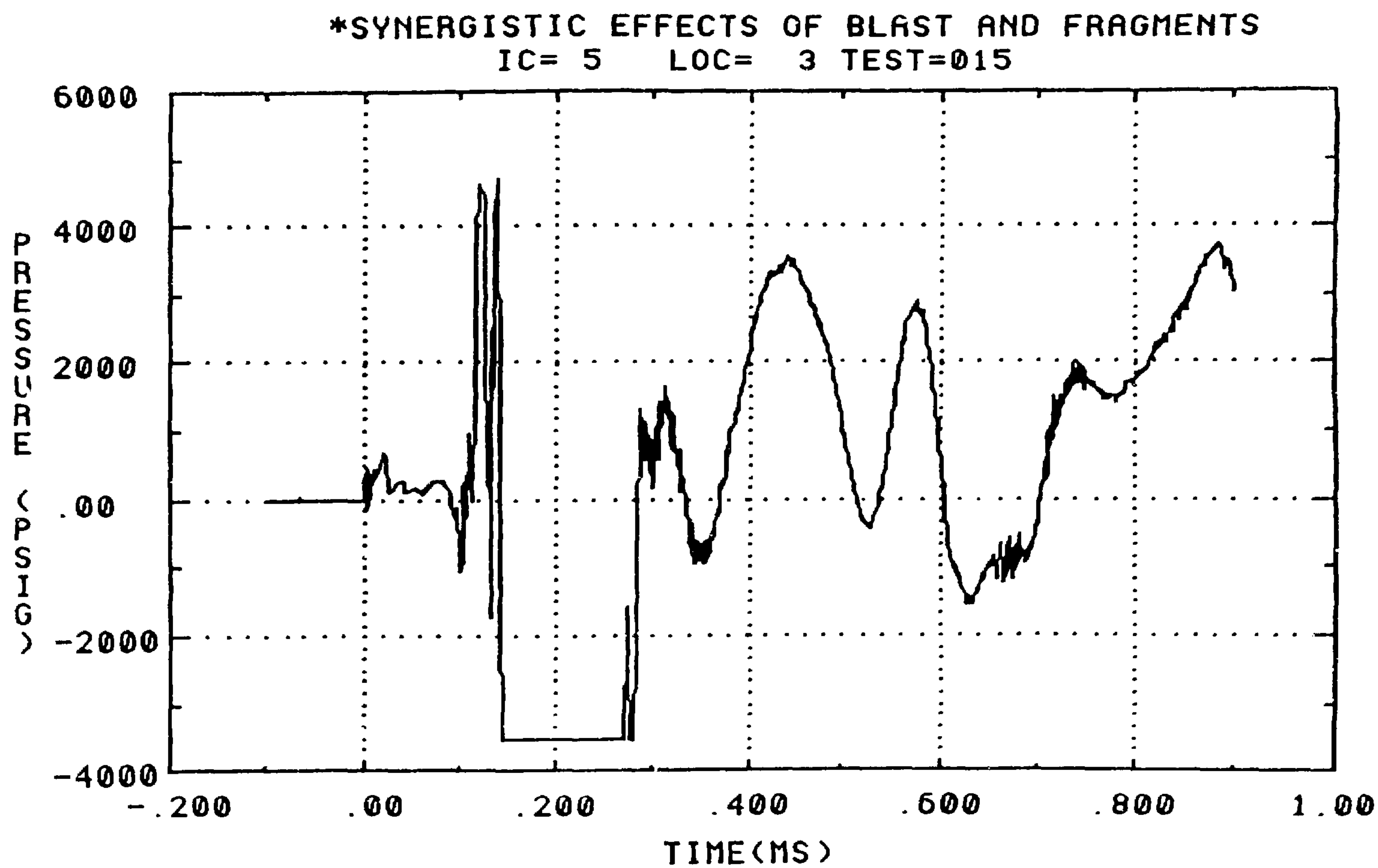


Figure C-25. Loads Test Data, Test 15, LOC 3

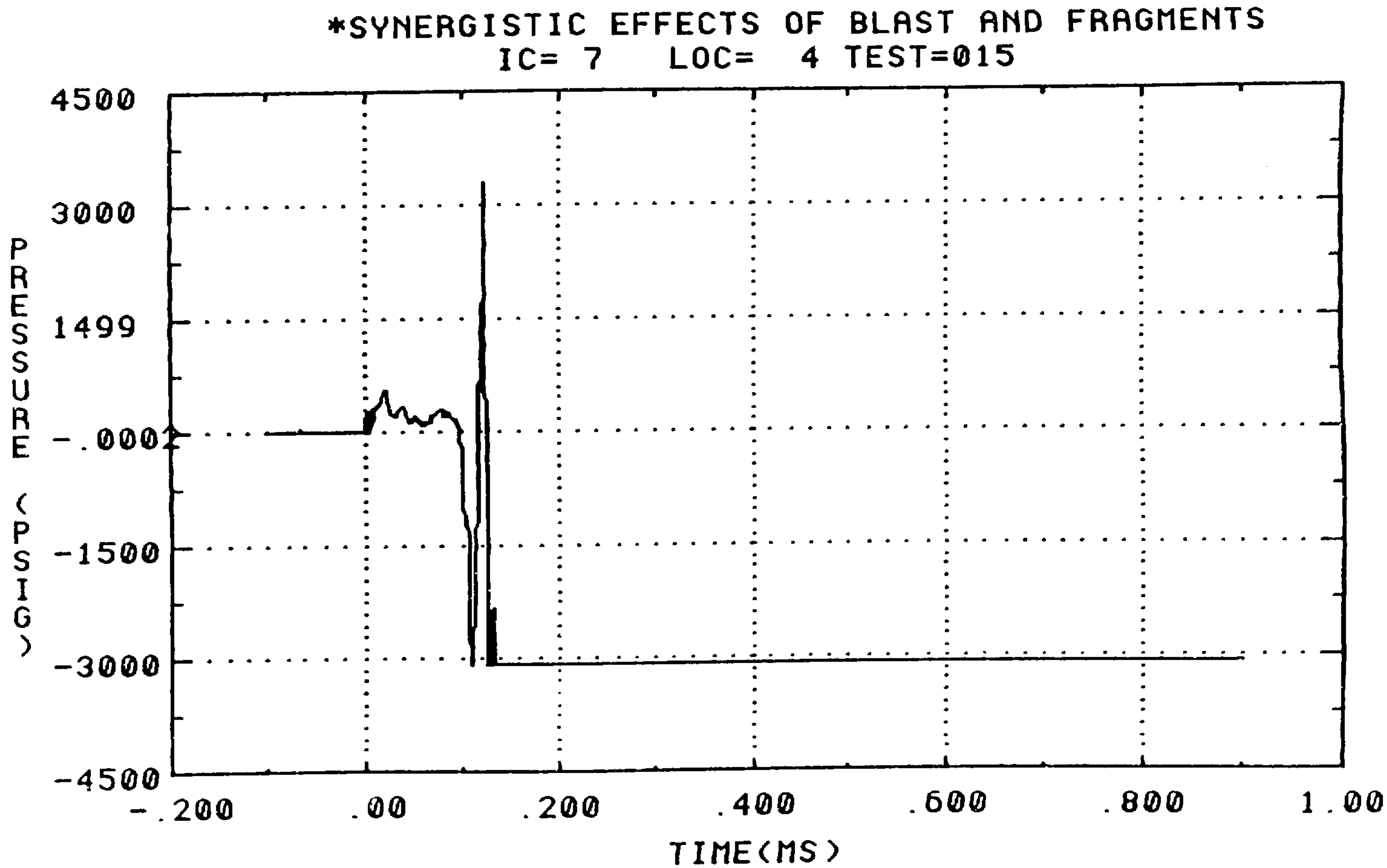


Figure C-26. Loads Test Data, Test 15, LOC 4

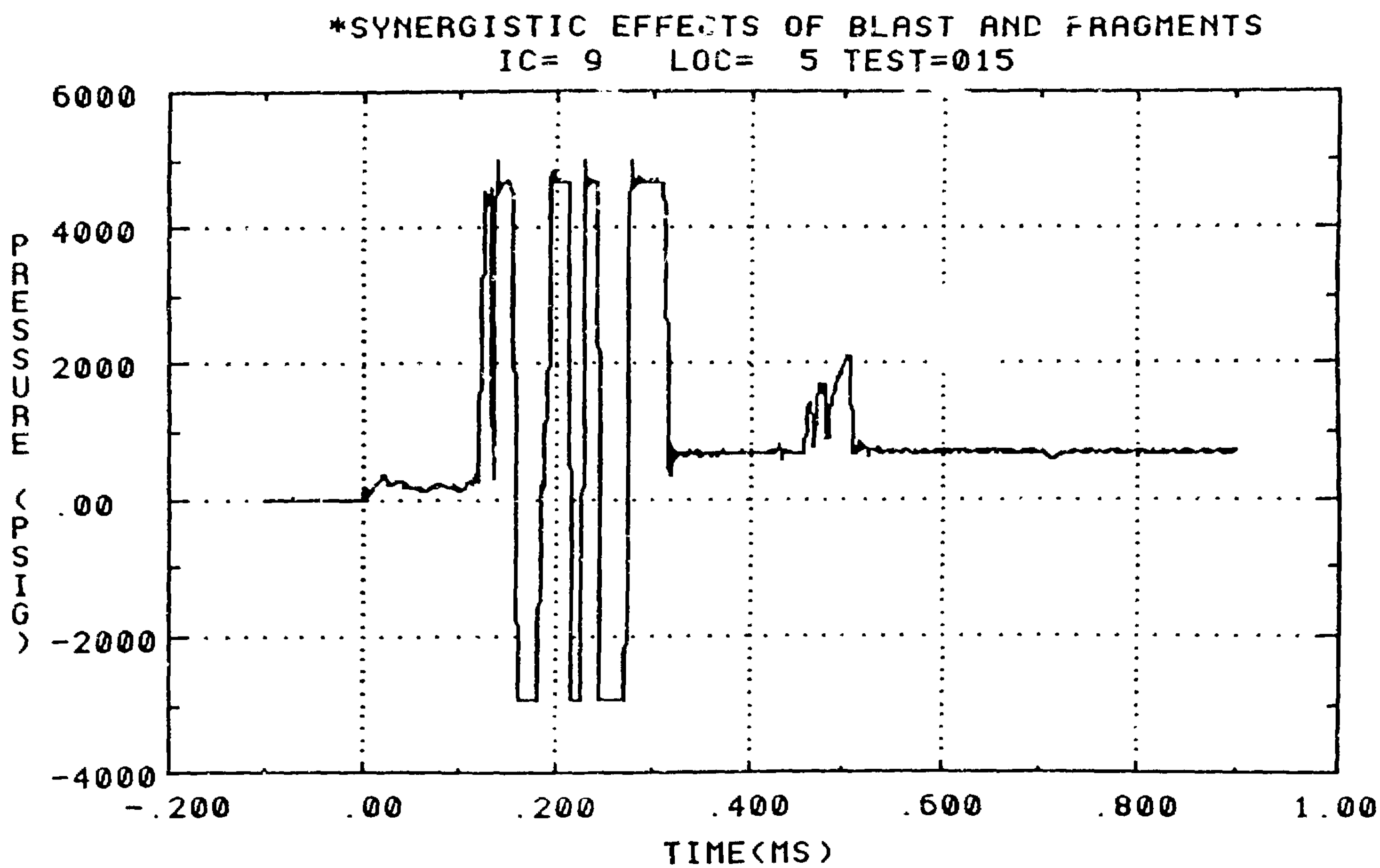


Figure C-27. Loads Test Data, Test 15, LOC 5

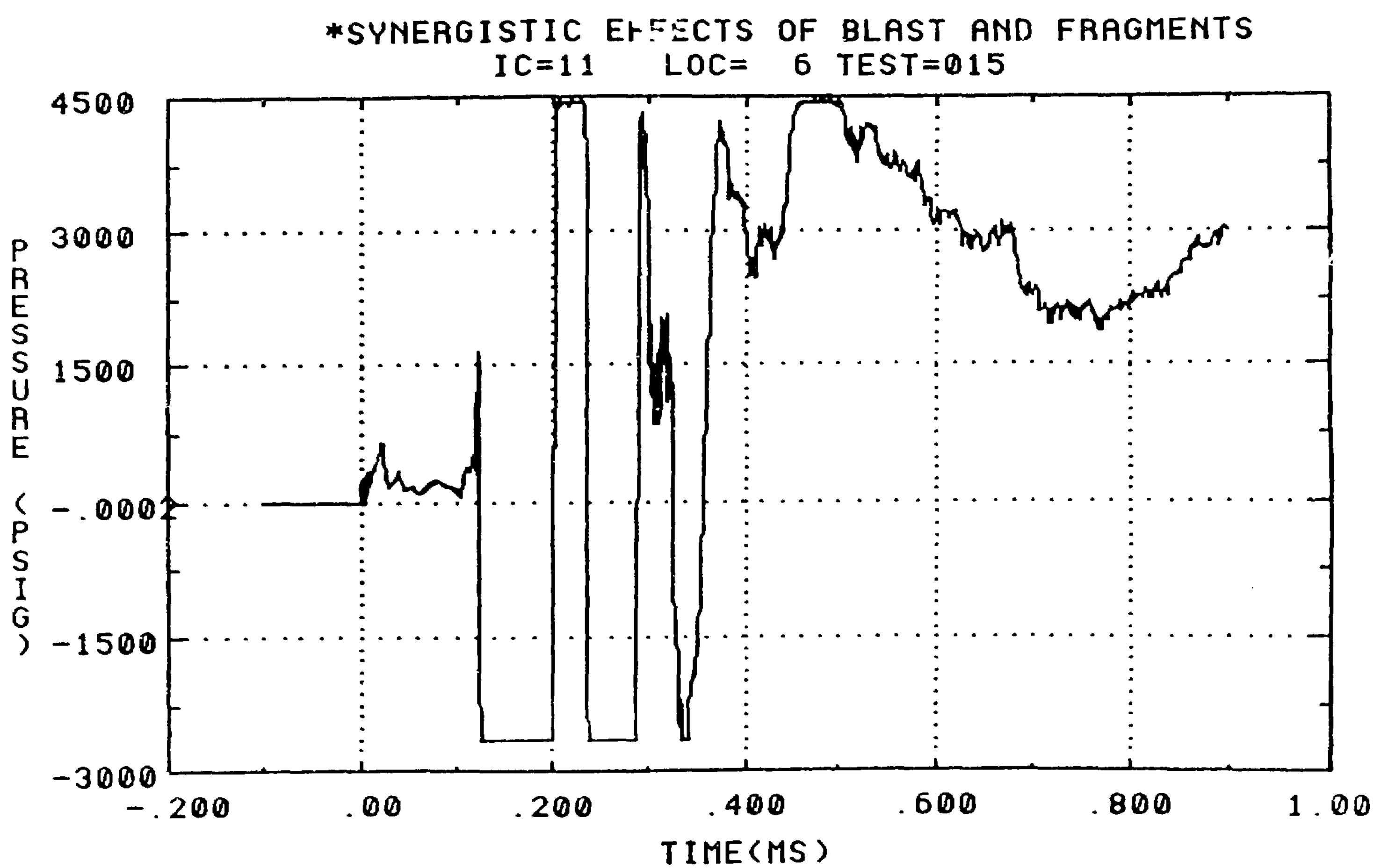


Figure C-28. Loads Test Data, Test 15, LOC 6

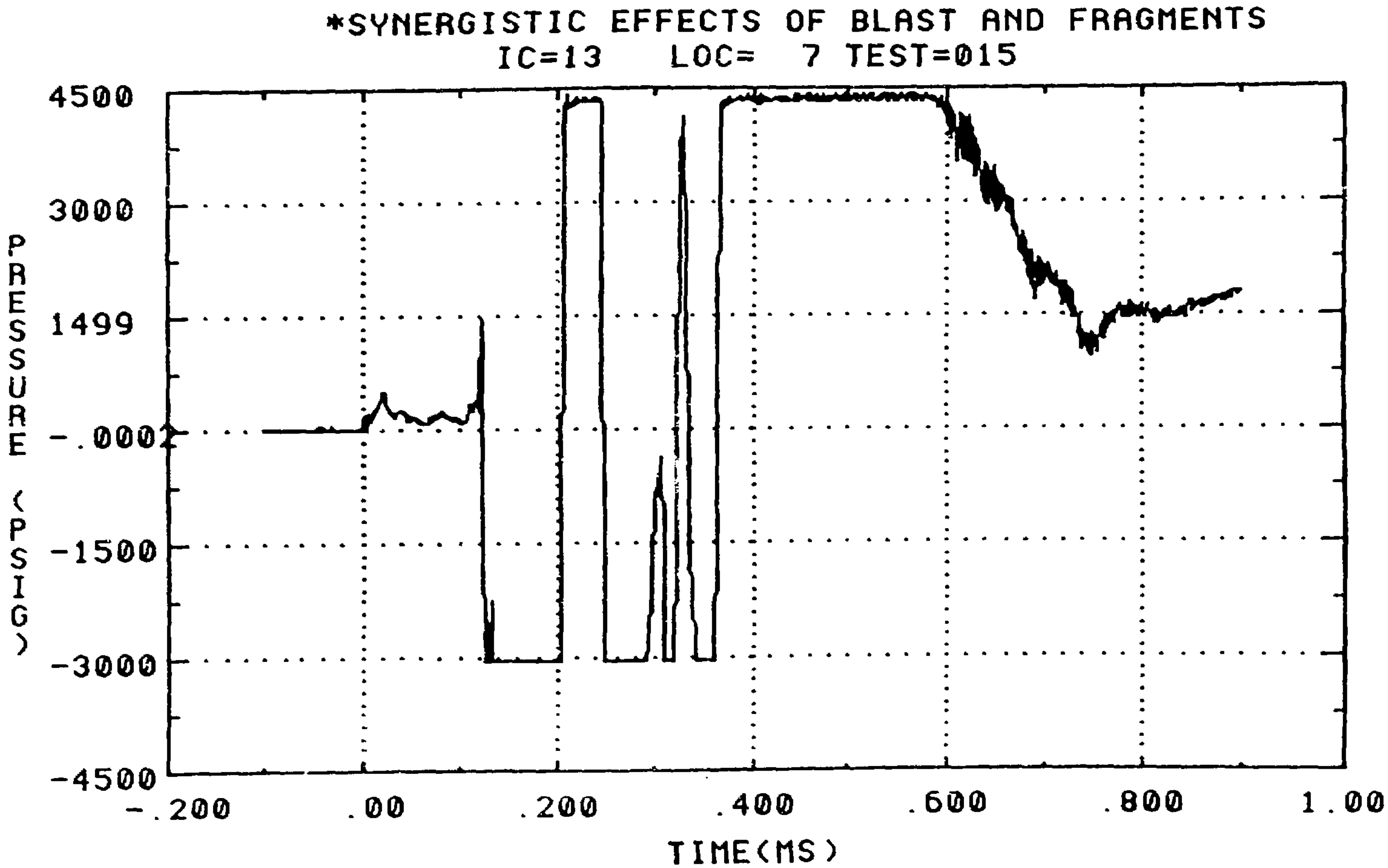


Figure C-29. Loads Test Data, Test 15, LOC 7

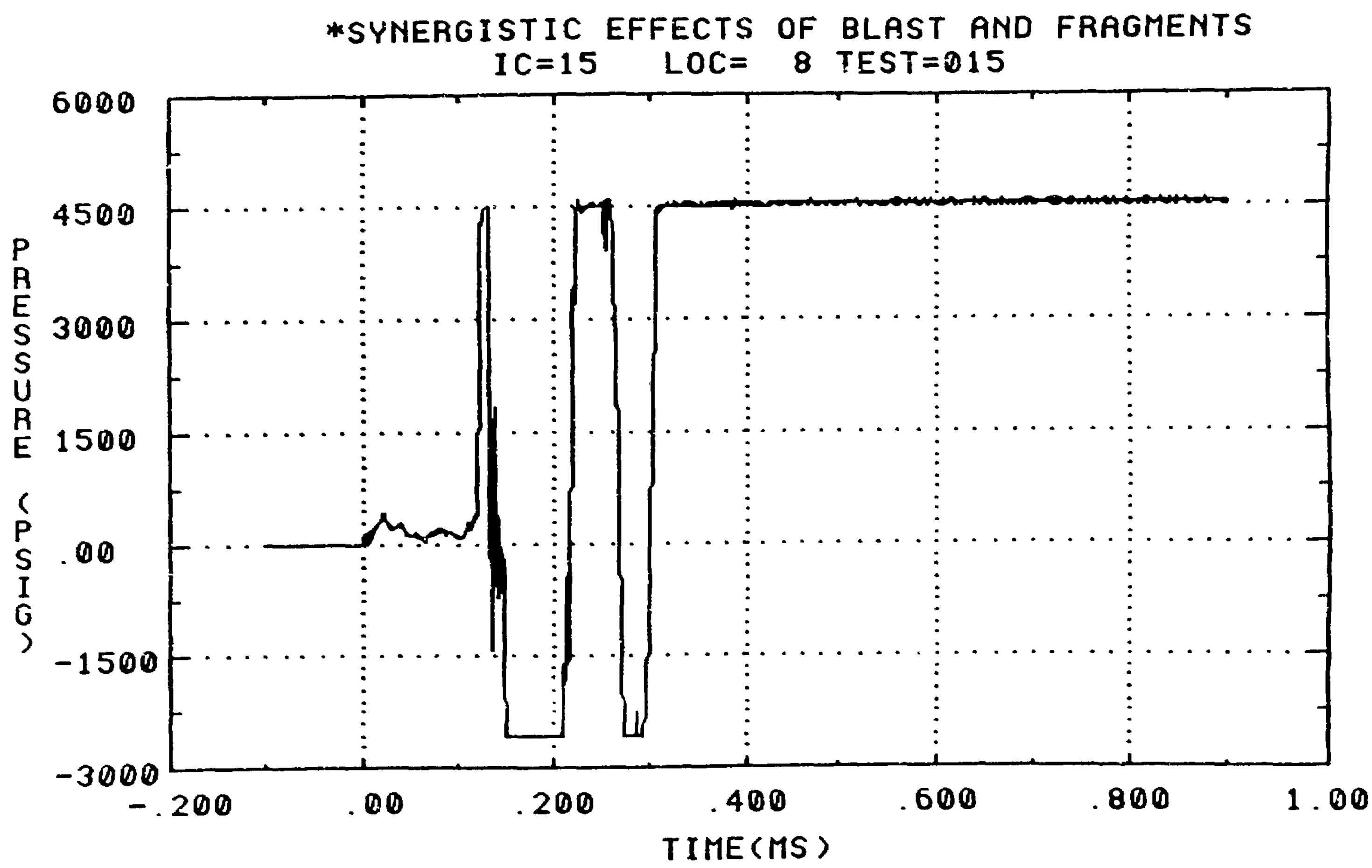


Figure C-30. Loads Test Data, Test 15, LOC 8

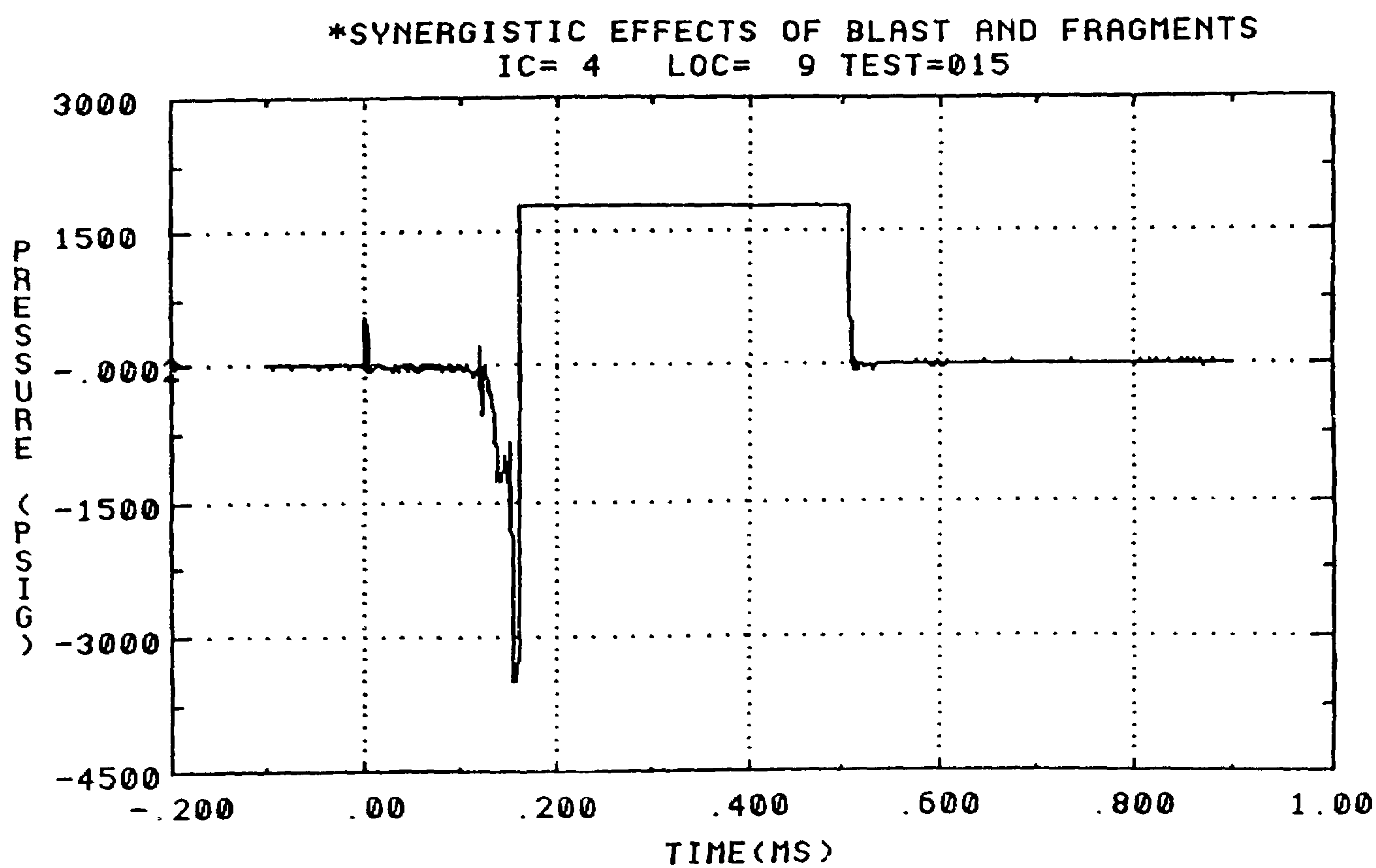


Figure C-31. Loads Test Data, Test 15, LOC 9

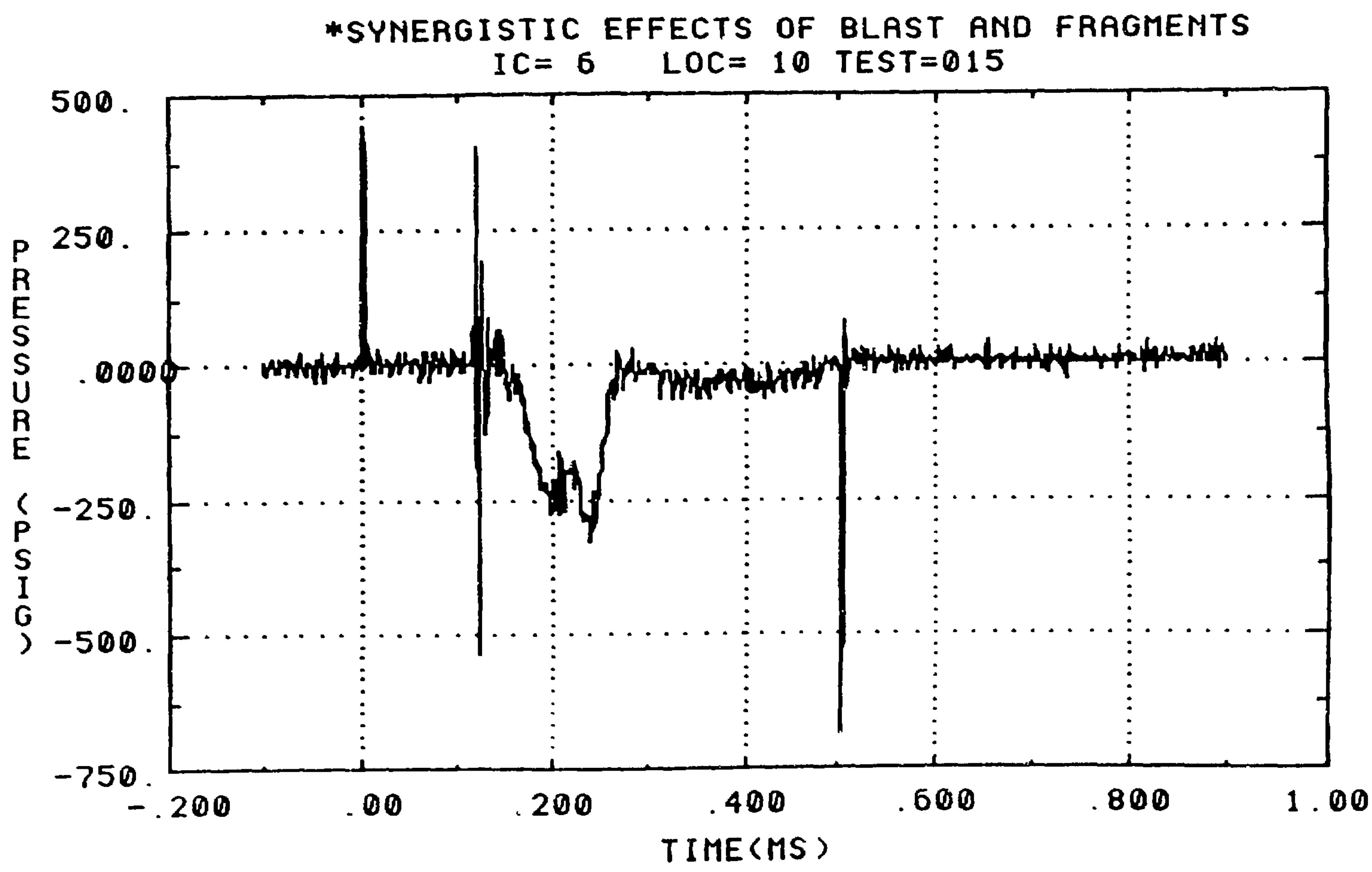


Figure C-32. Loads Test Data, Test 15, LOC 10

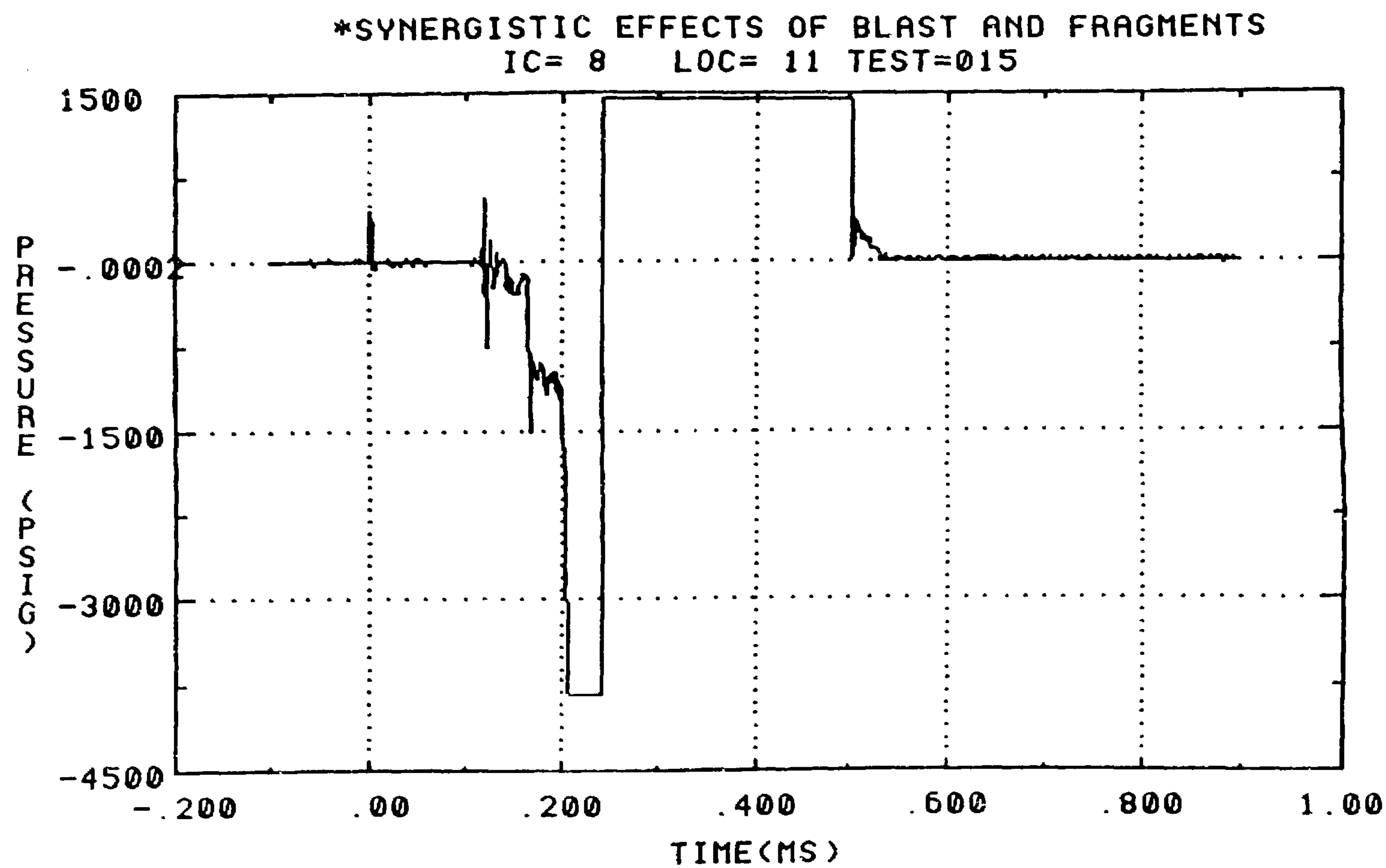


Figure C-33. Loads Test Data, Test 15, LOC 11

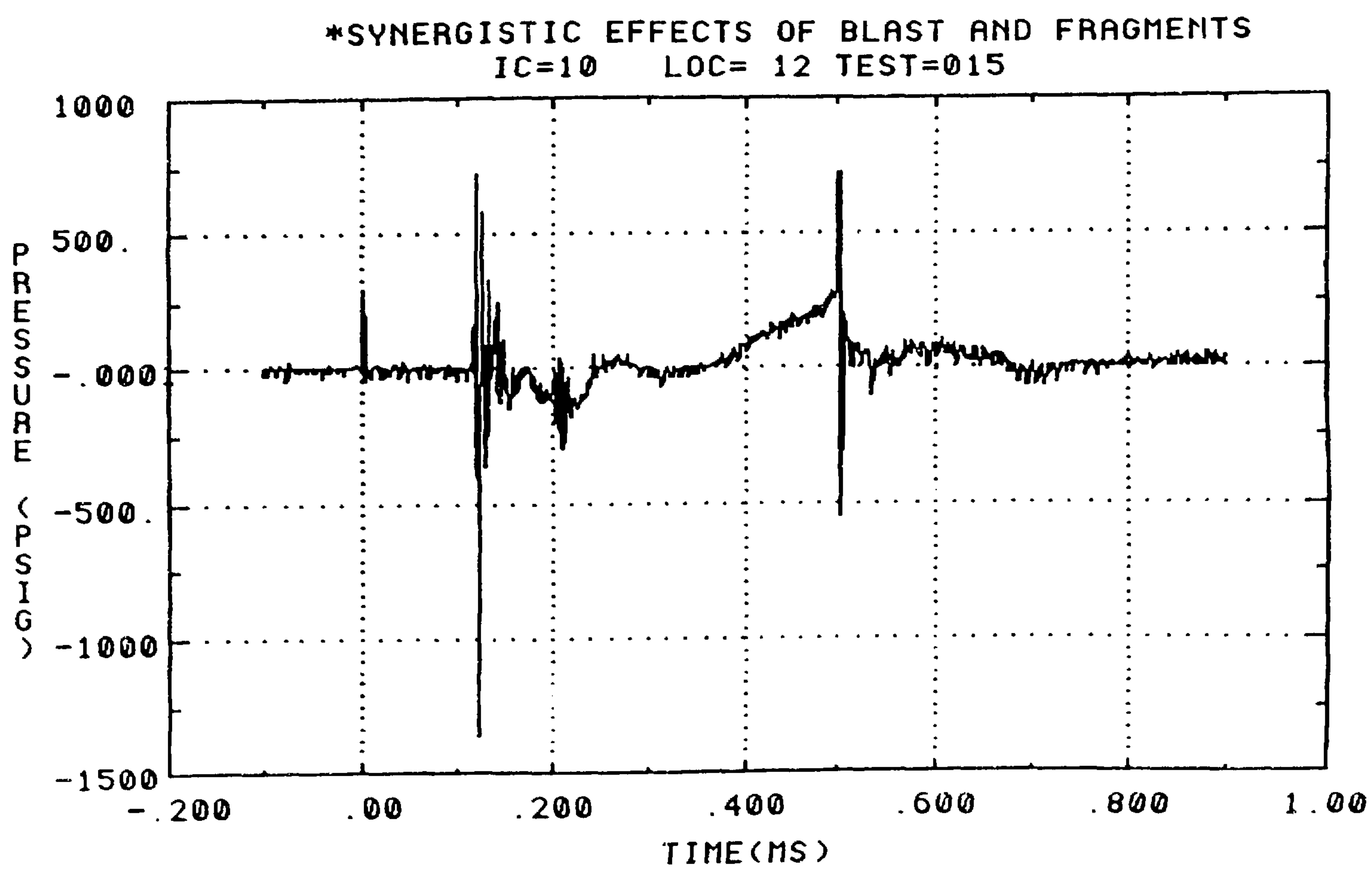


Figure C-34. Loads Test Data, Test 15, LOC 12

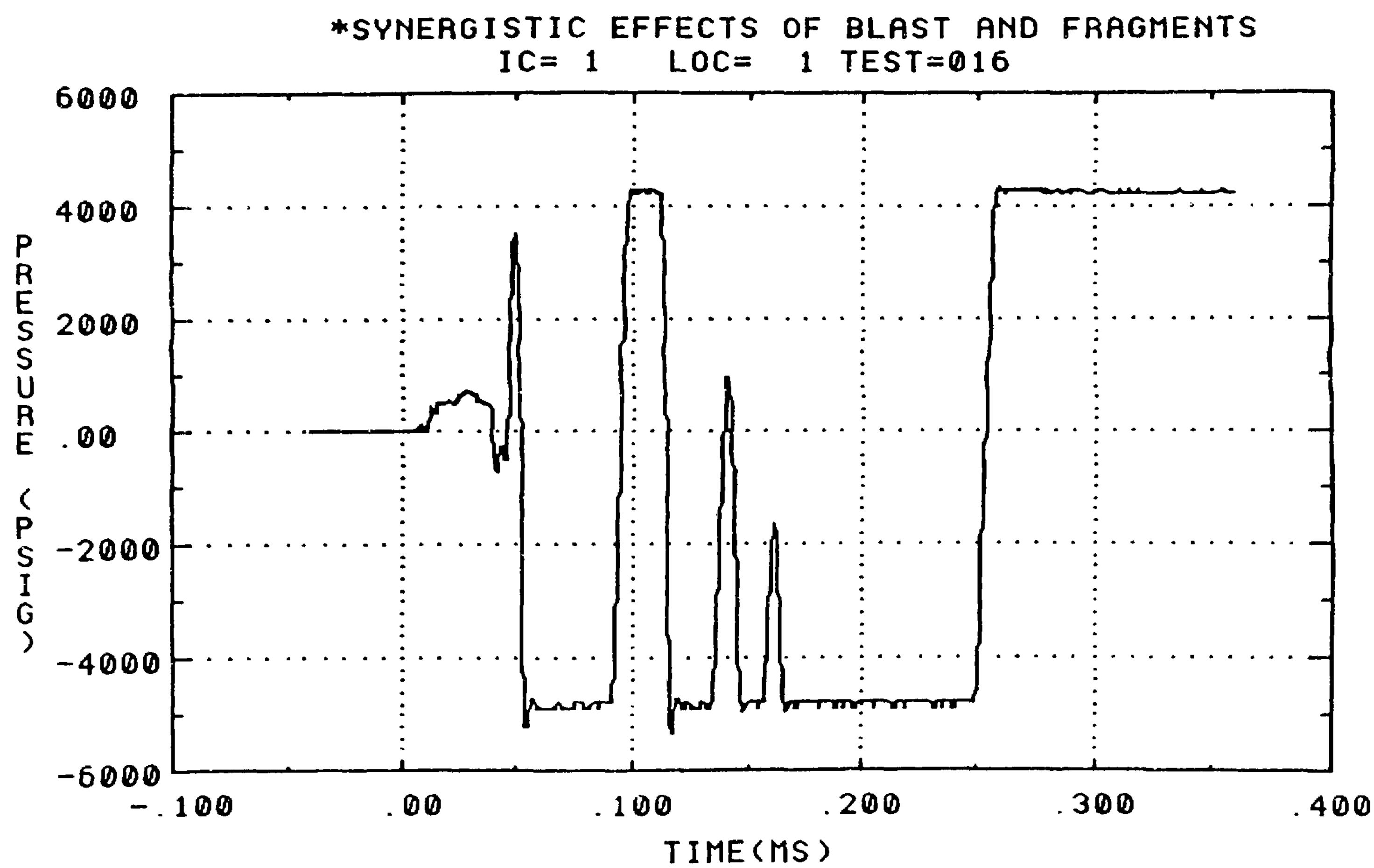


Figure C-35. Loads Test Data, Test 16, LOC 1

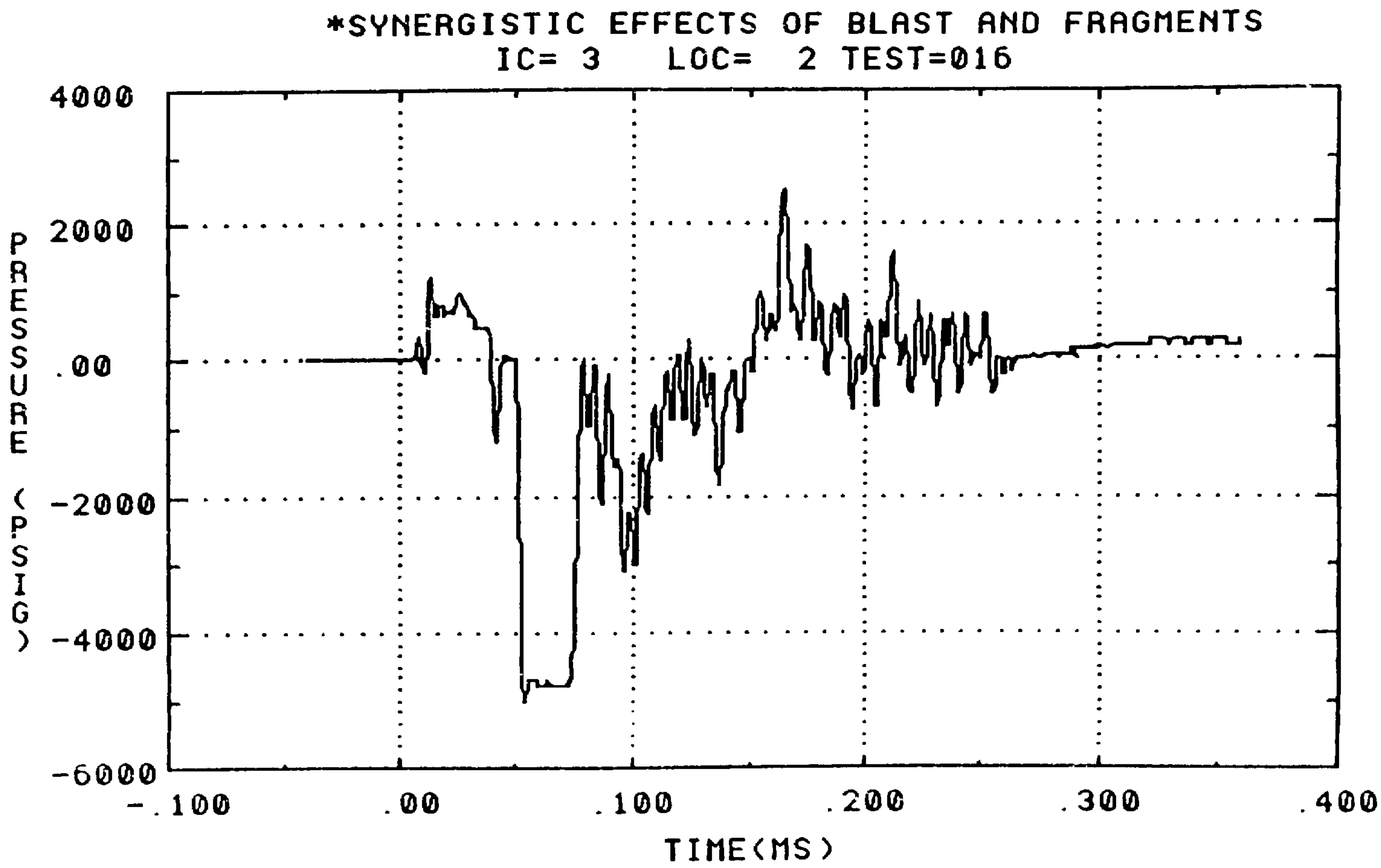


Figure C-36. Loads Test Data, Test 16, LOC 2

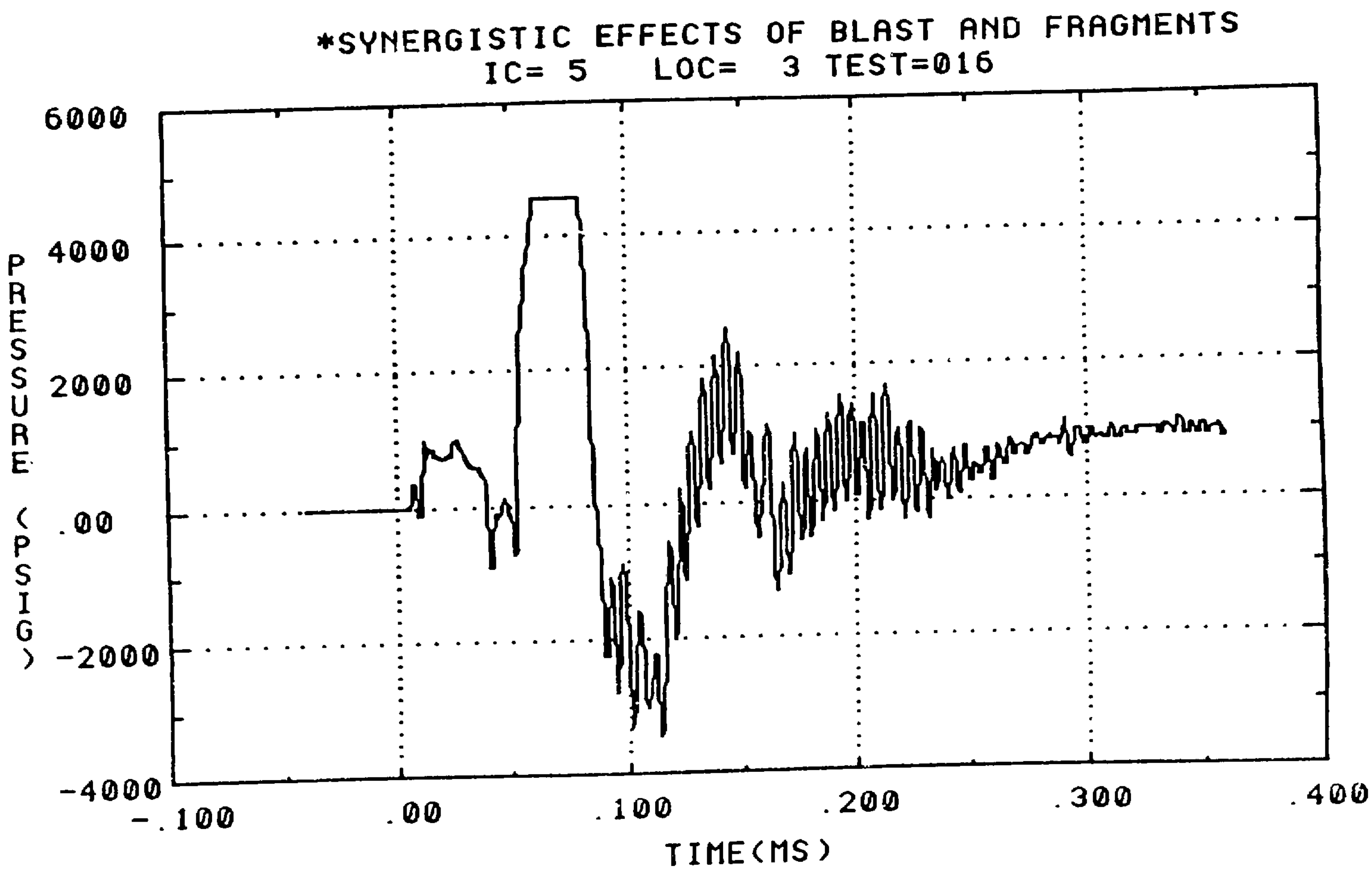


Figure C-37. Loads Test Data, Test 16, LOC 3

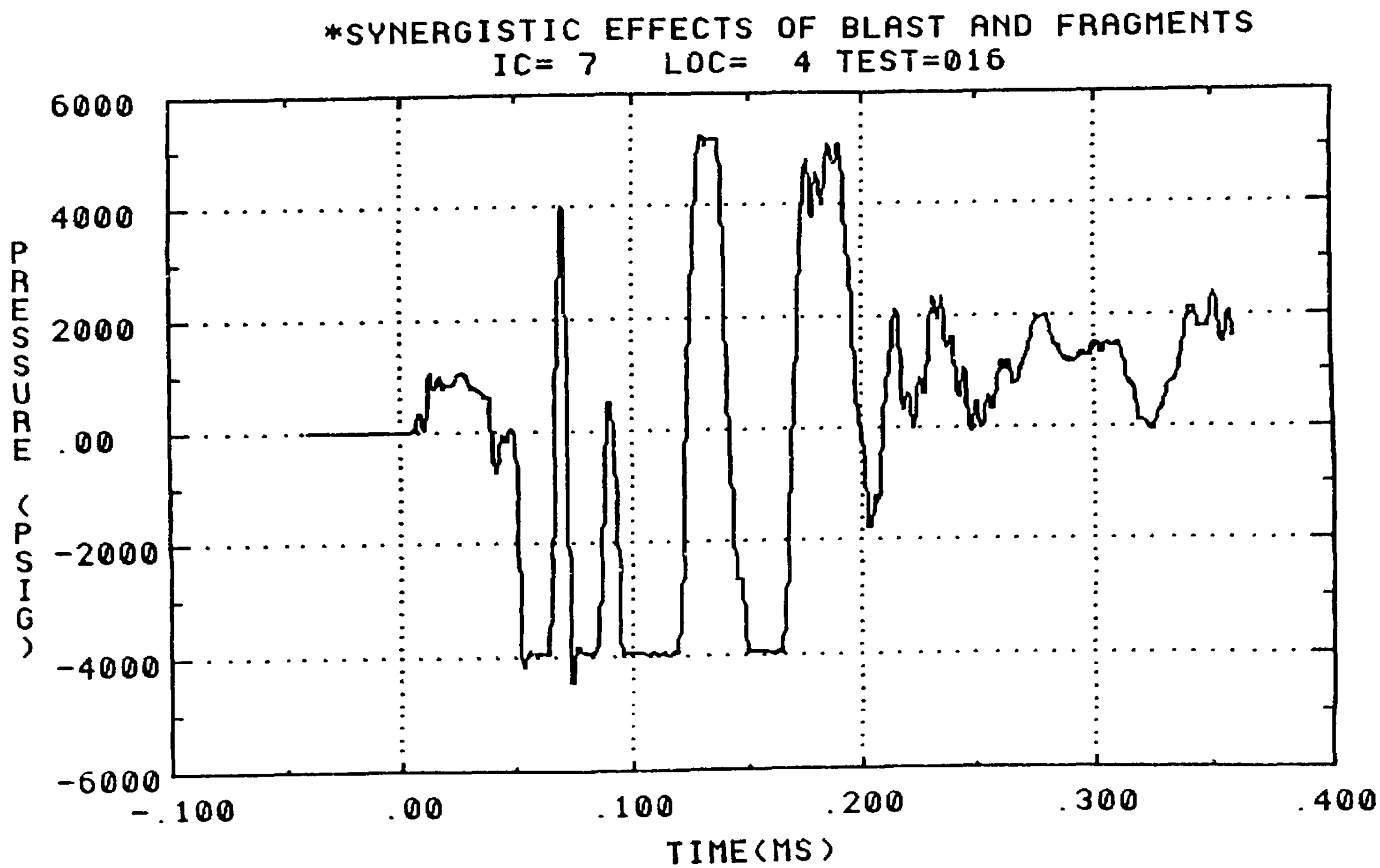


Figure C-38. Loads Test Data, Test 16, LOC 4

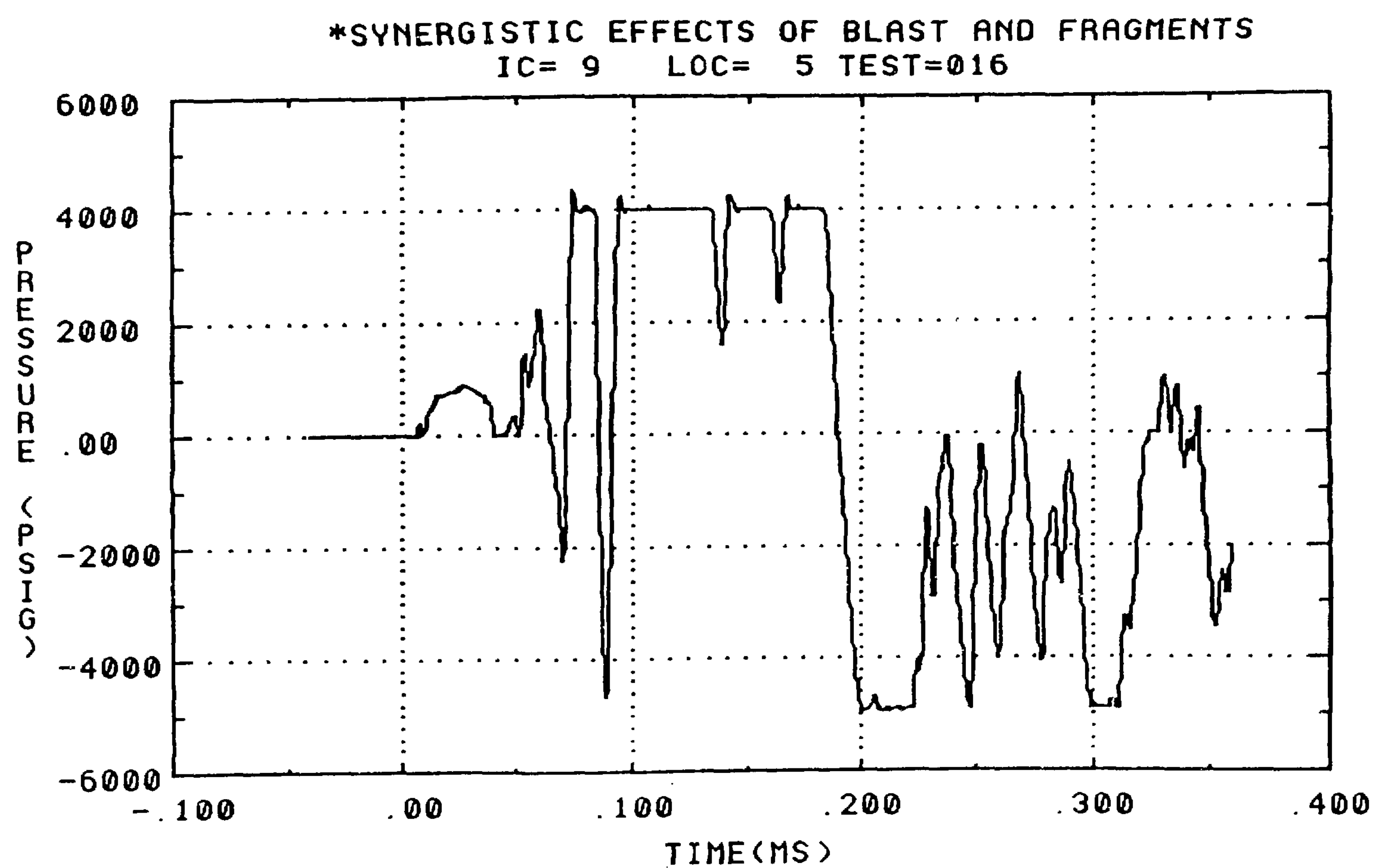


Figure C-39. Loads Test Data, Test 16, LOC 5

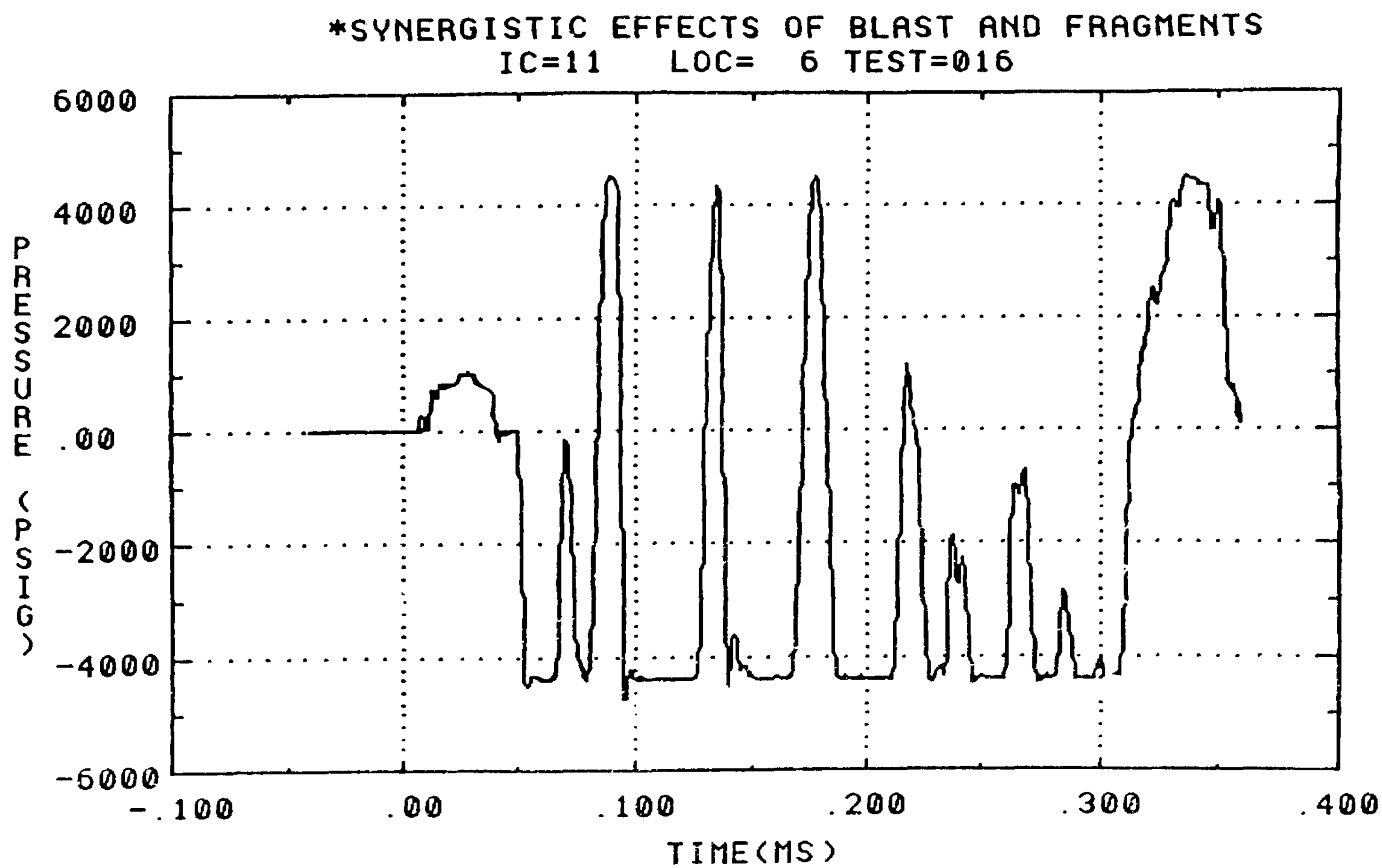


Figure C-40. Loads Test Data, Test 16, LOC 6

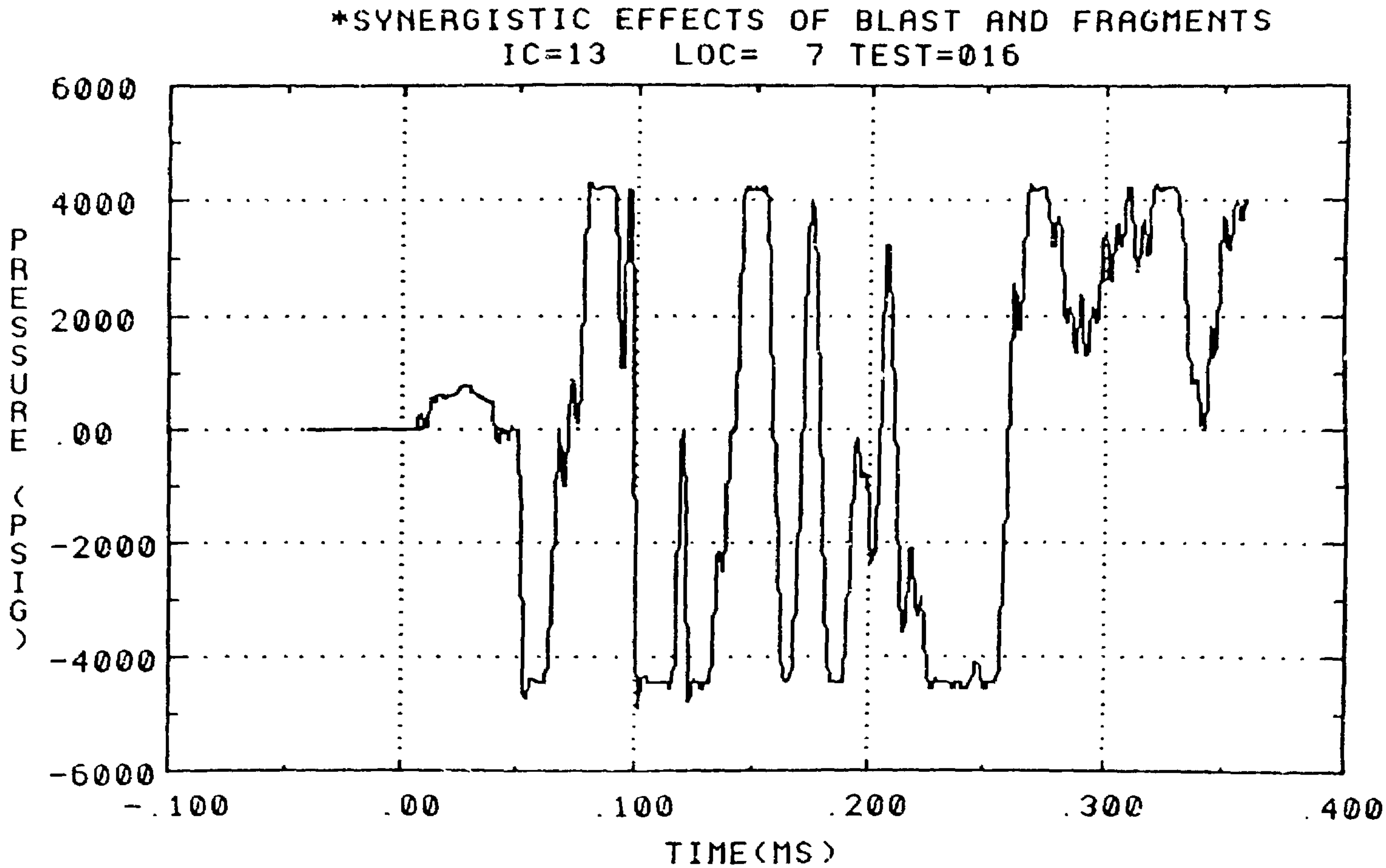


Figure C-41. Loads Test Data, Test 16, LOC 7

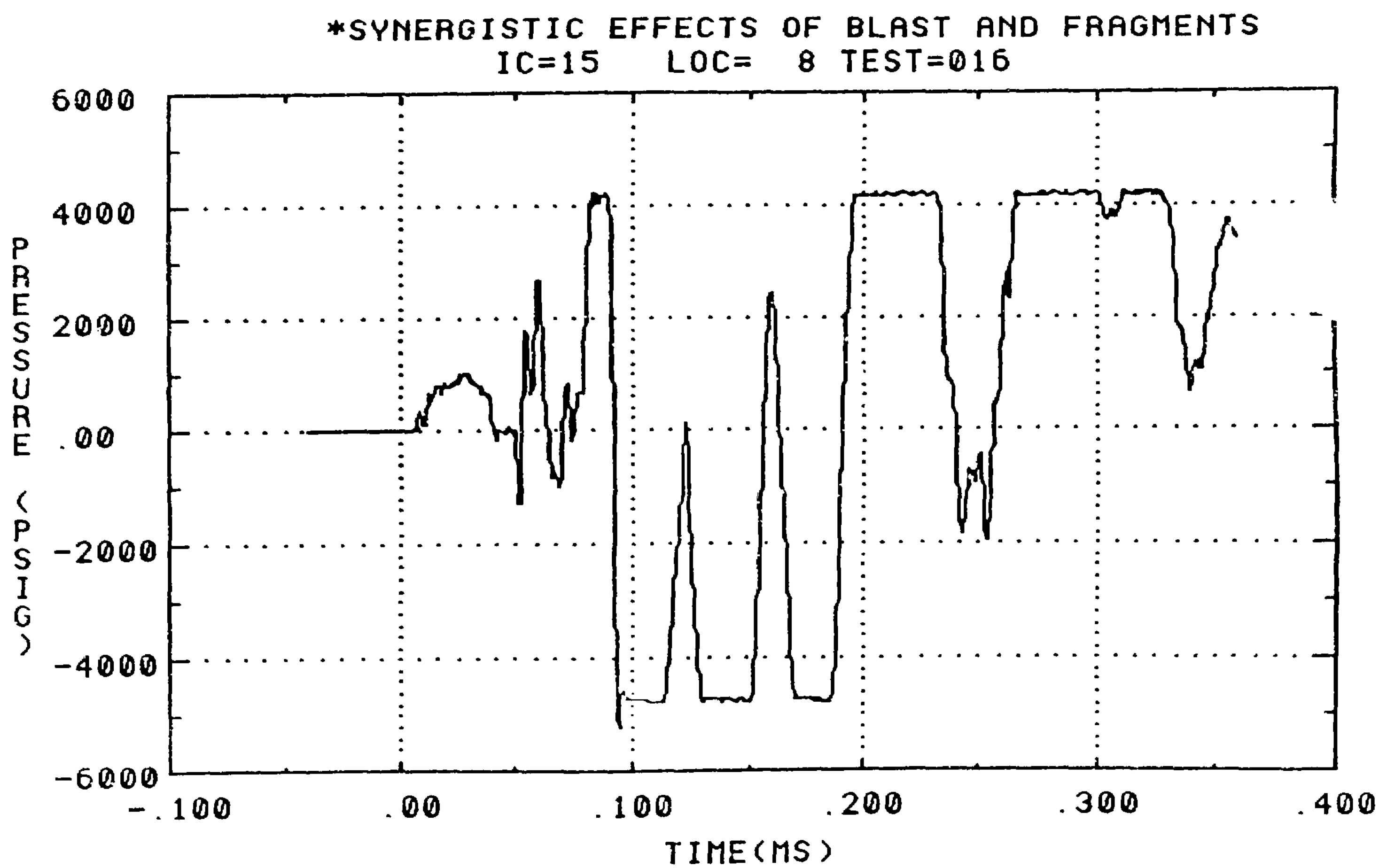


Figure C-42. Loads Test Data, Test 16, LOC 8

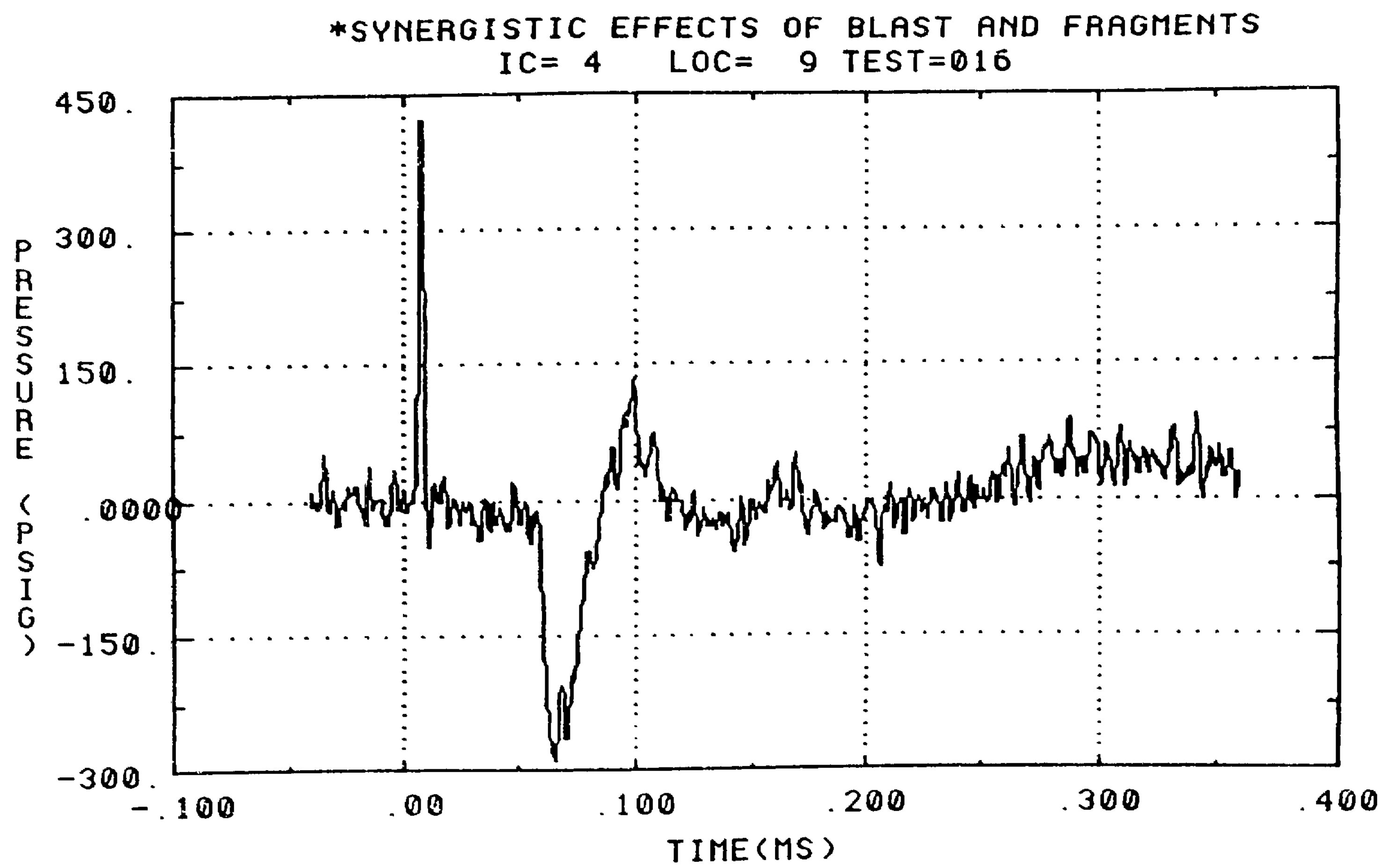


Figure C-43. Loads Test Data, Test 16, LOC 9

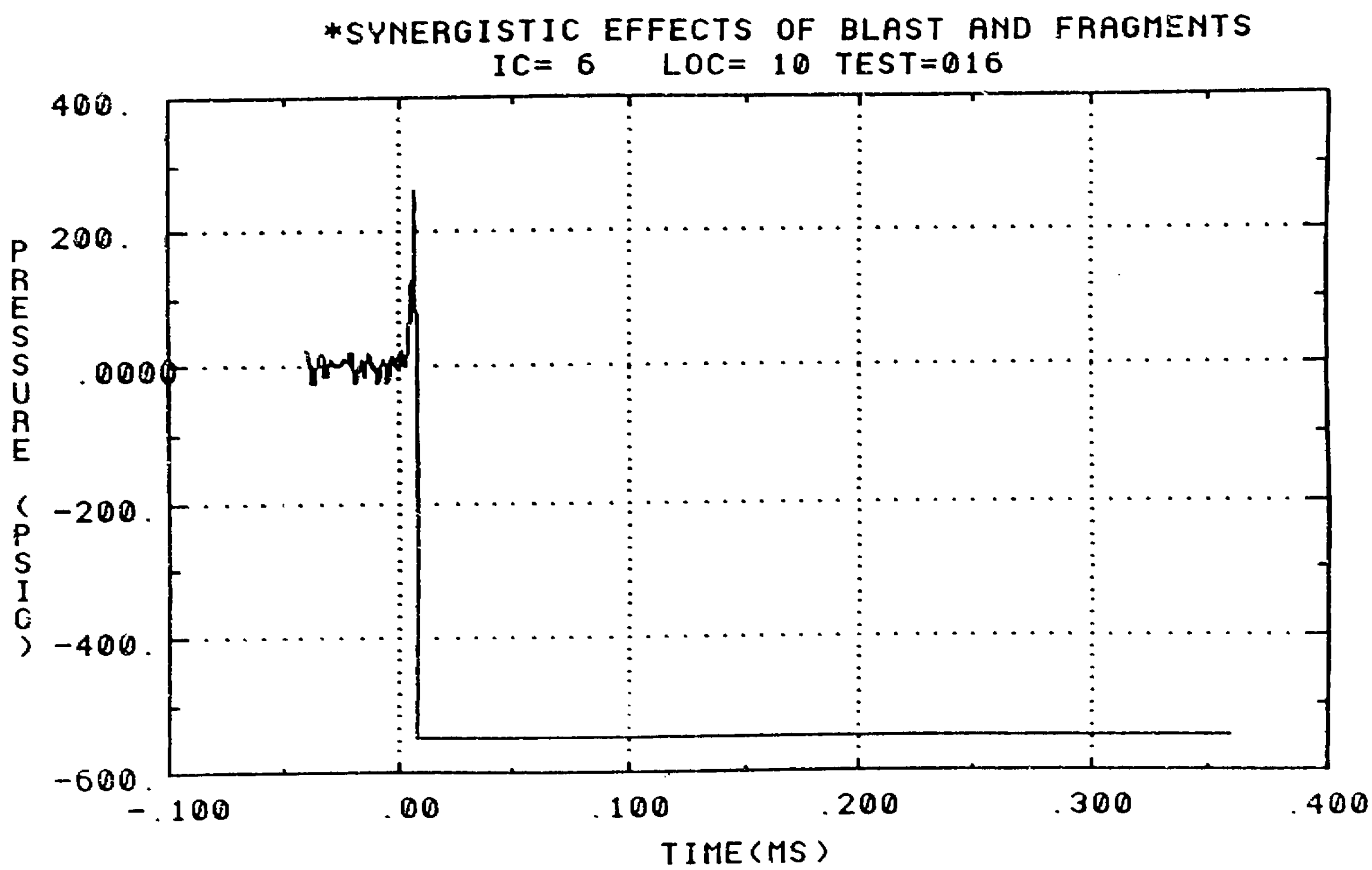


Figure C-44. Loads Test Data, Test 16, LOC 10

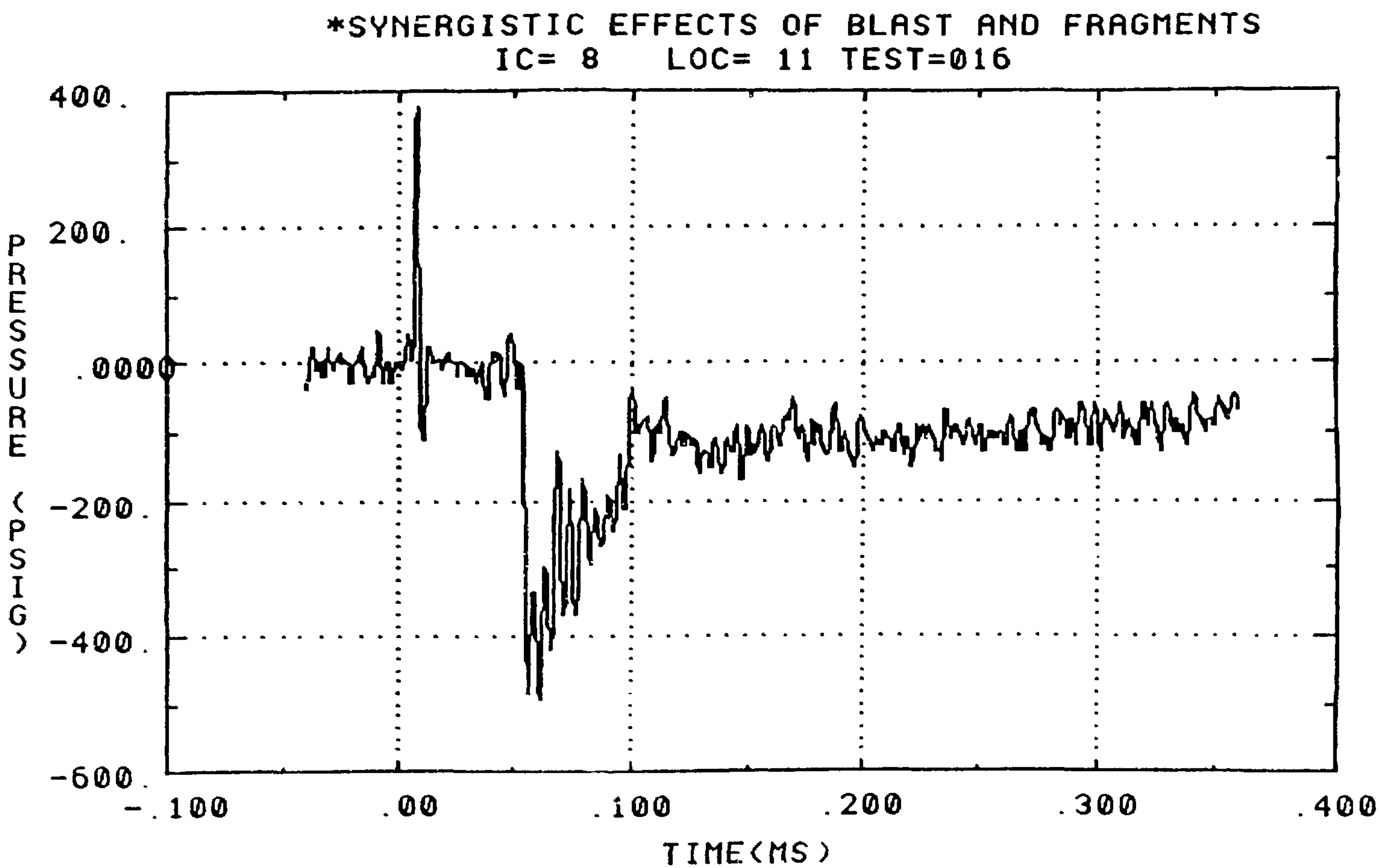


Figure C-45. Loads Test Data, Test 16, LOC 11

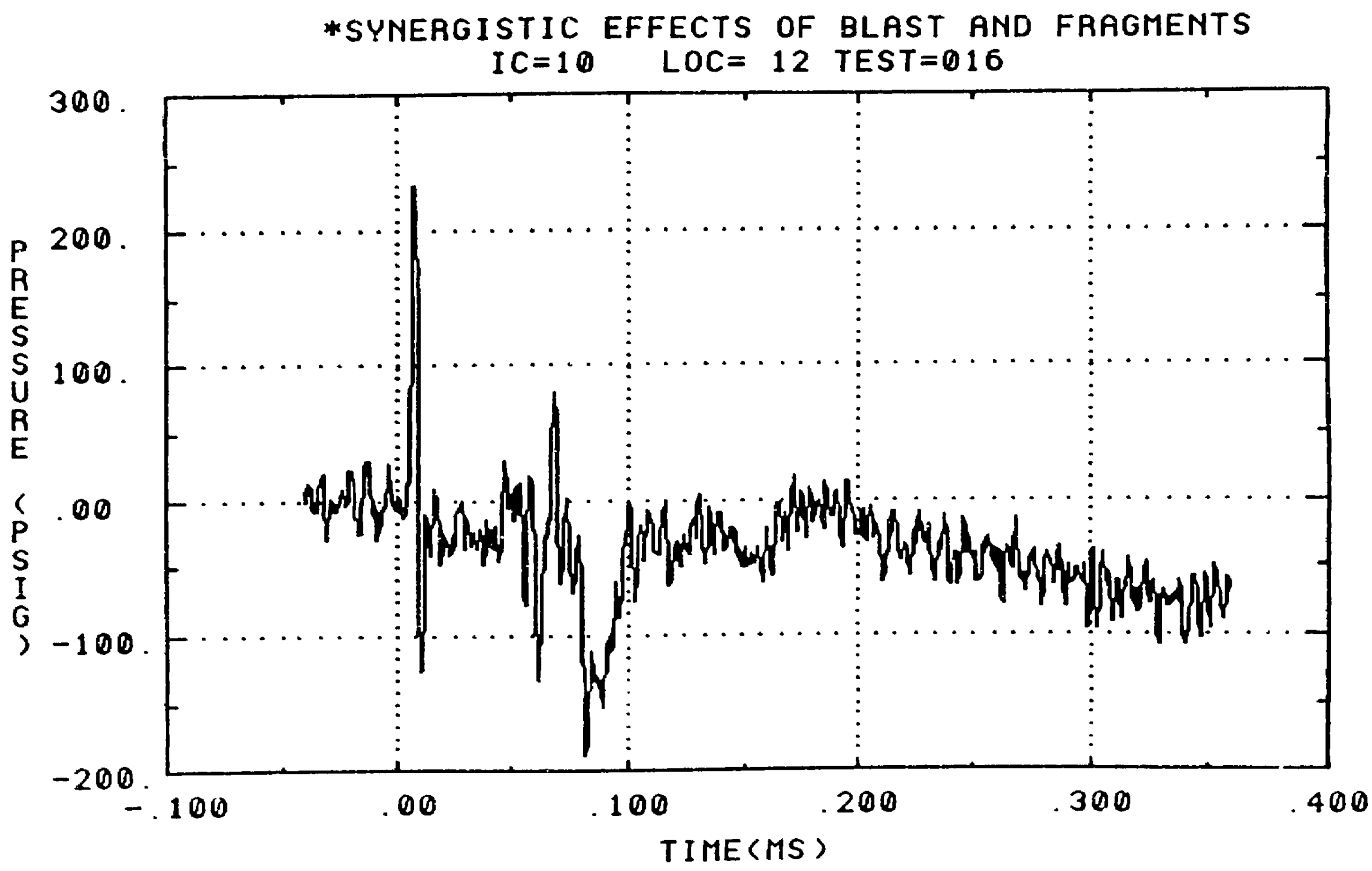


Figure C-46. Loads Test Data, Test 16, LOC 12

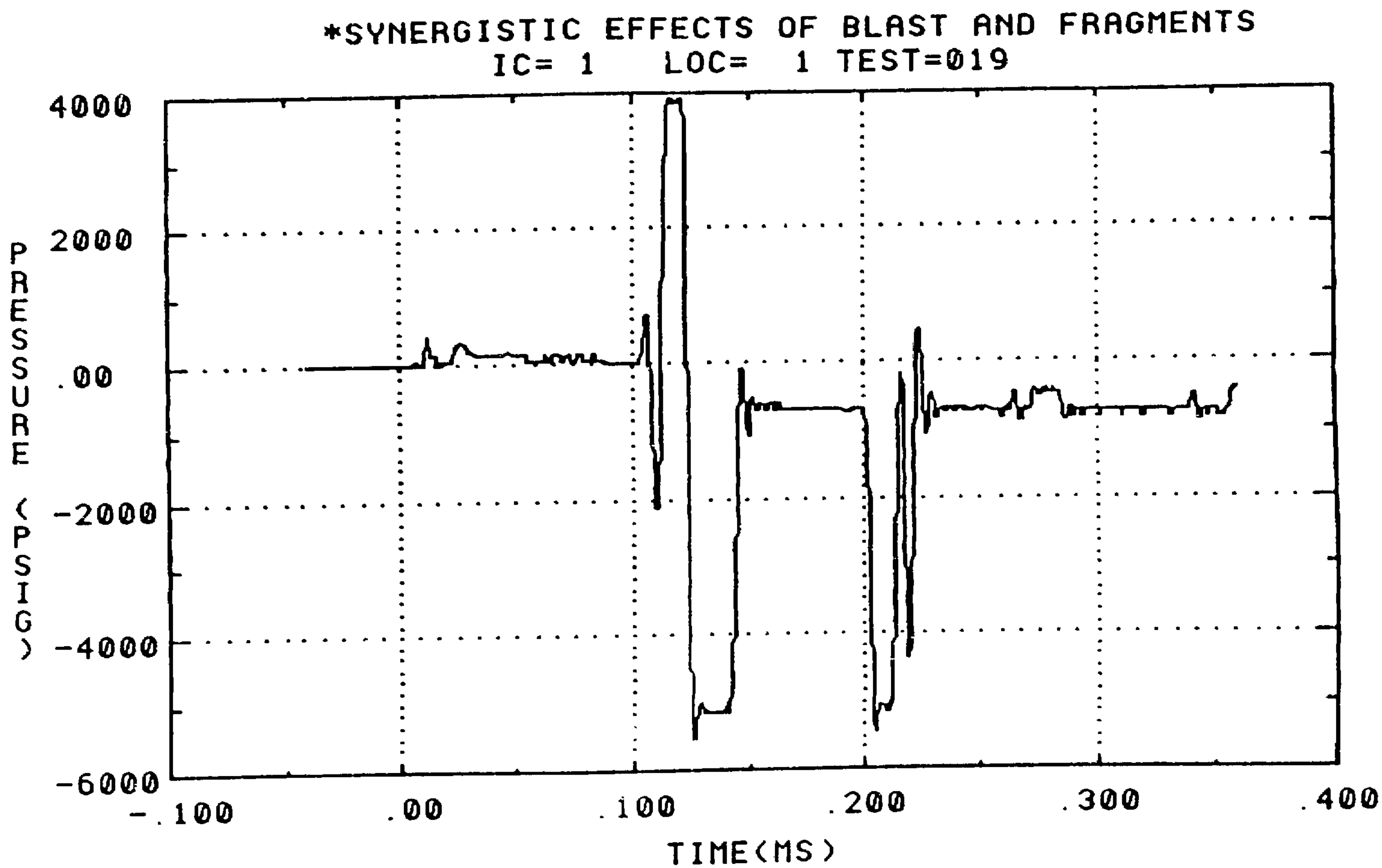


Figure C-47. Loads Test Data, Test 19, LOC 1

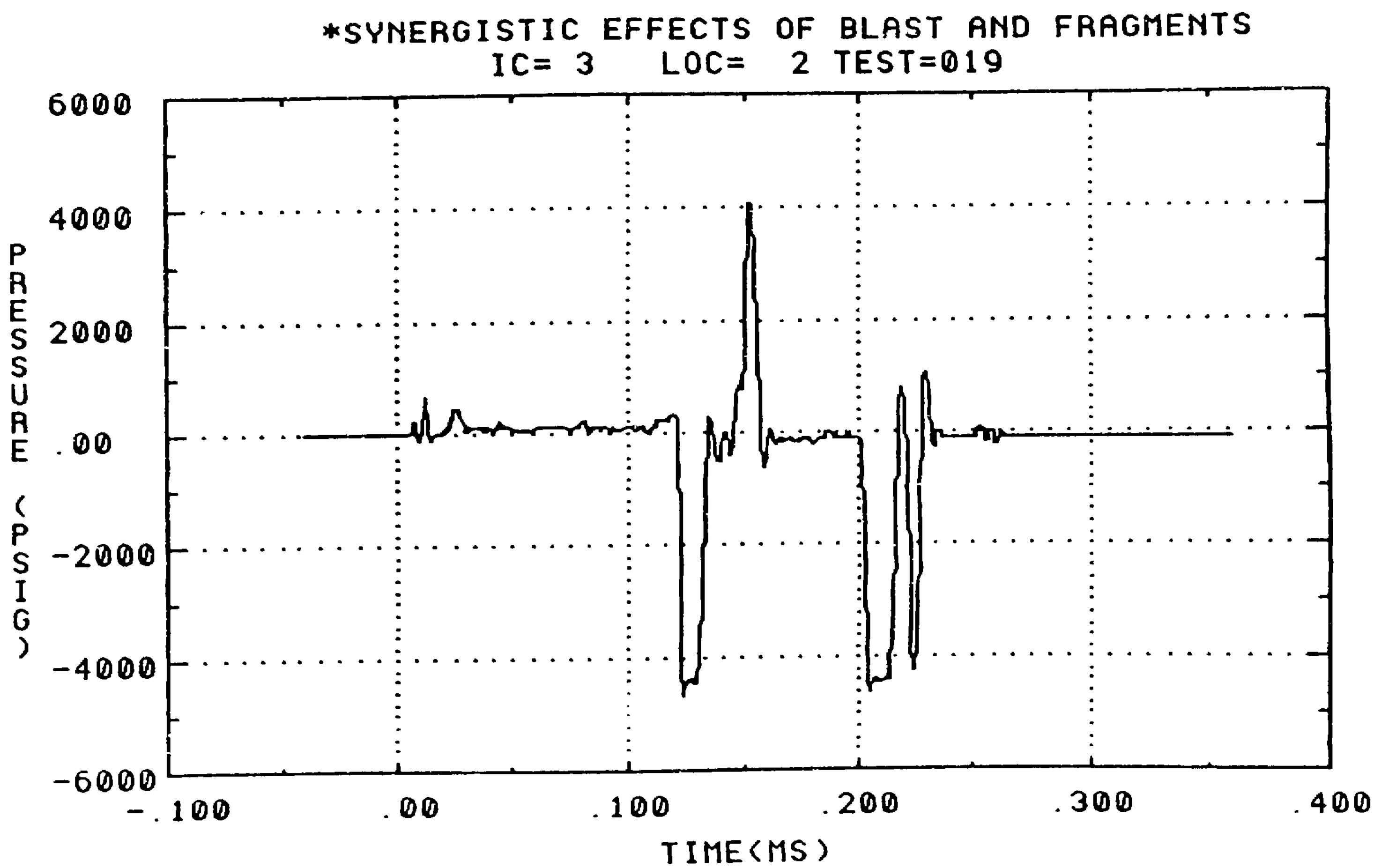


Figure C-48. Loads Test Data, Test 19, LOC 2

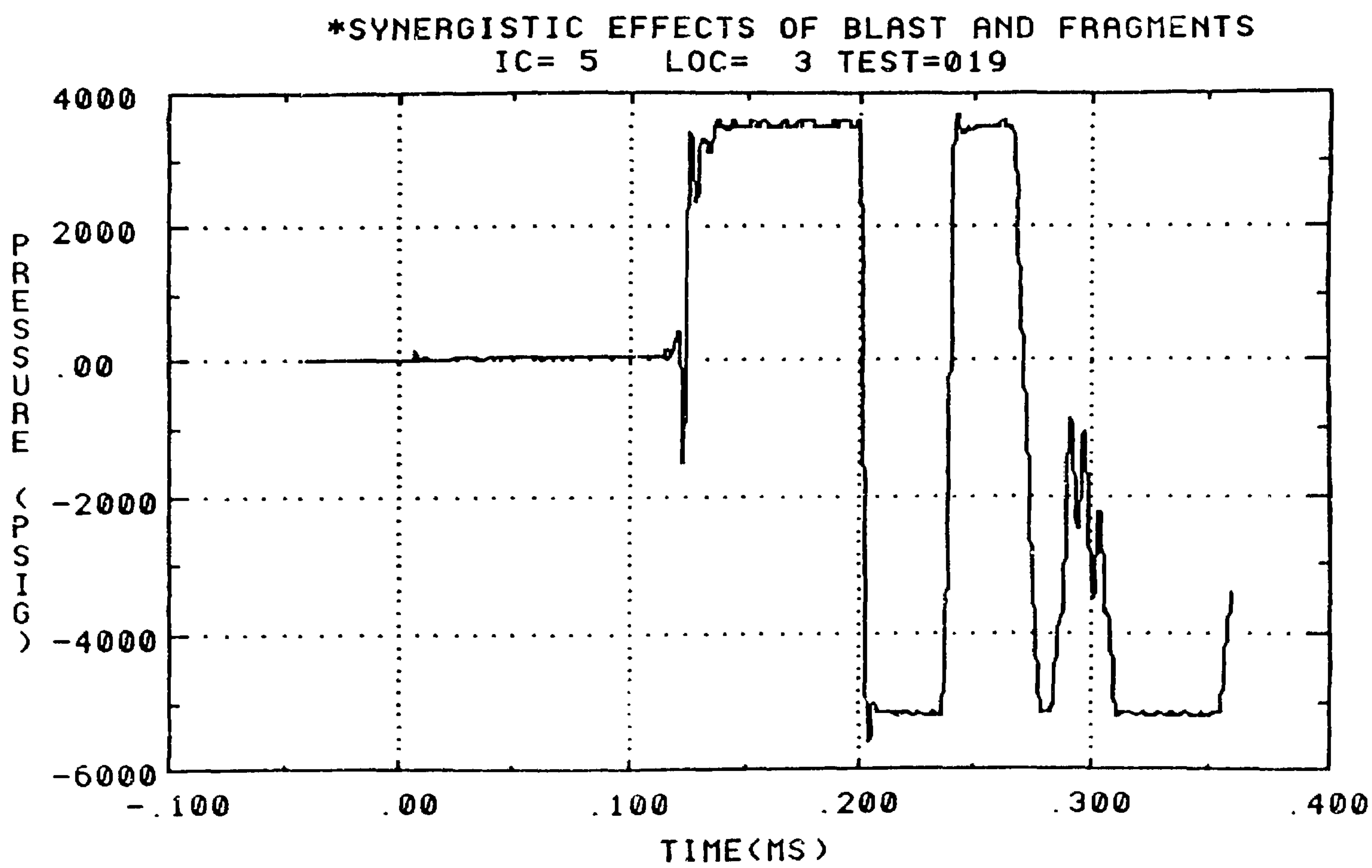


Figure C-49. Loads Test Data, Test 19, LOC 3

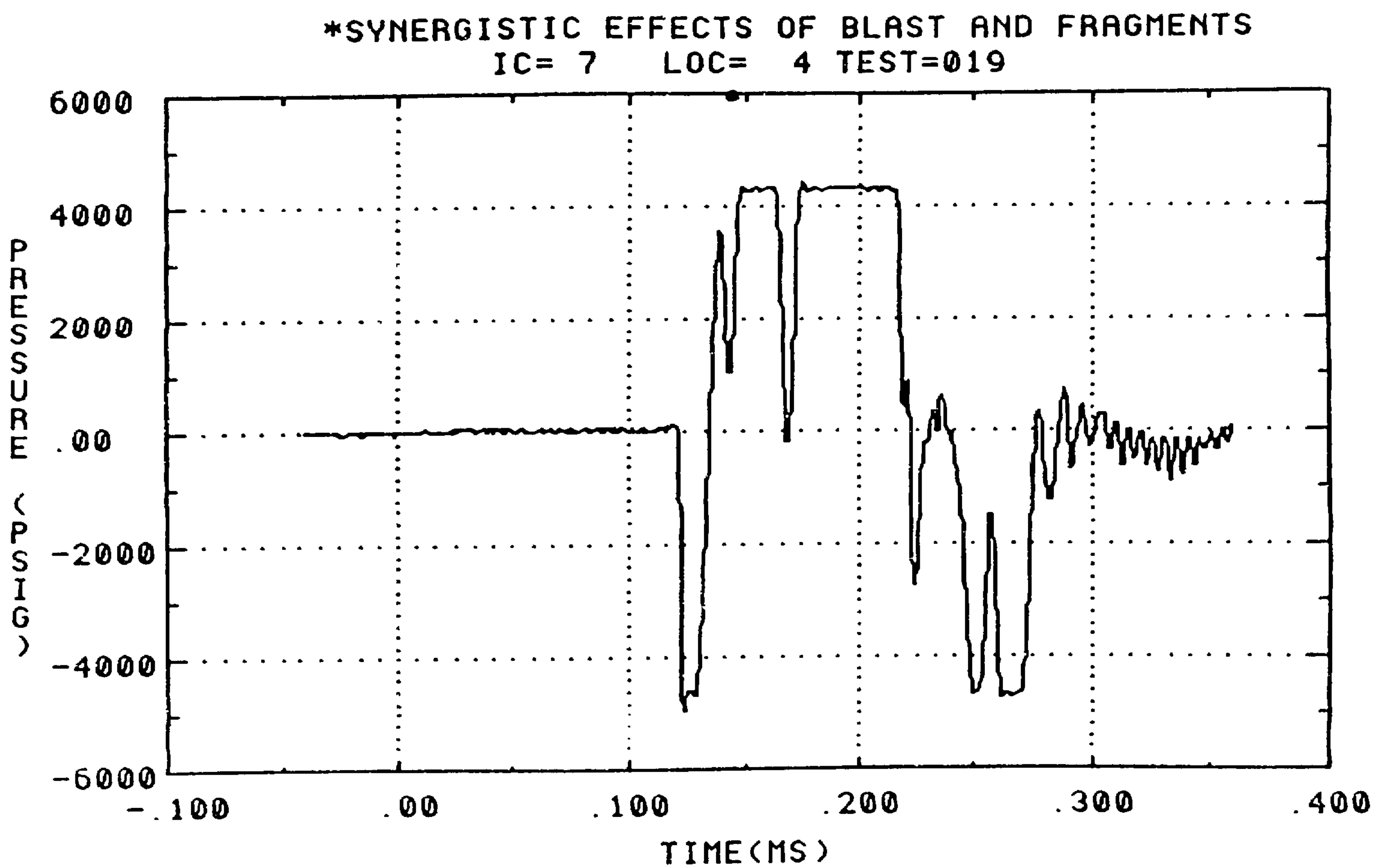


Figure C-50. Loads Test Data, Test 19, LOC 4

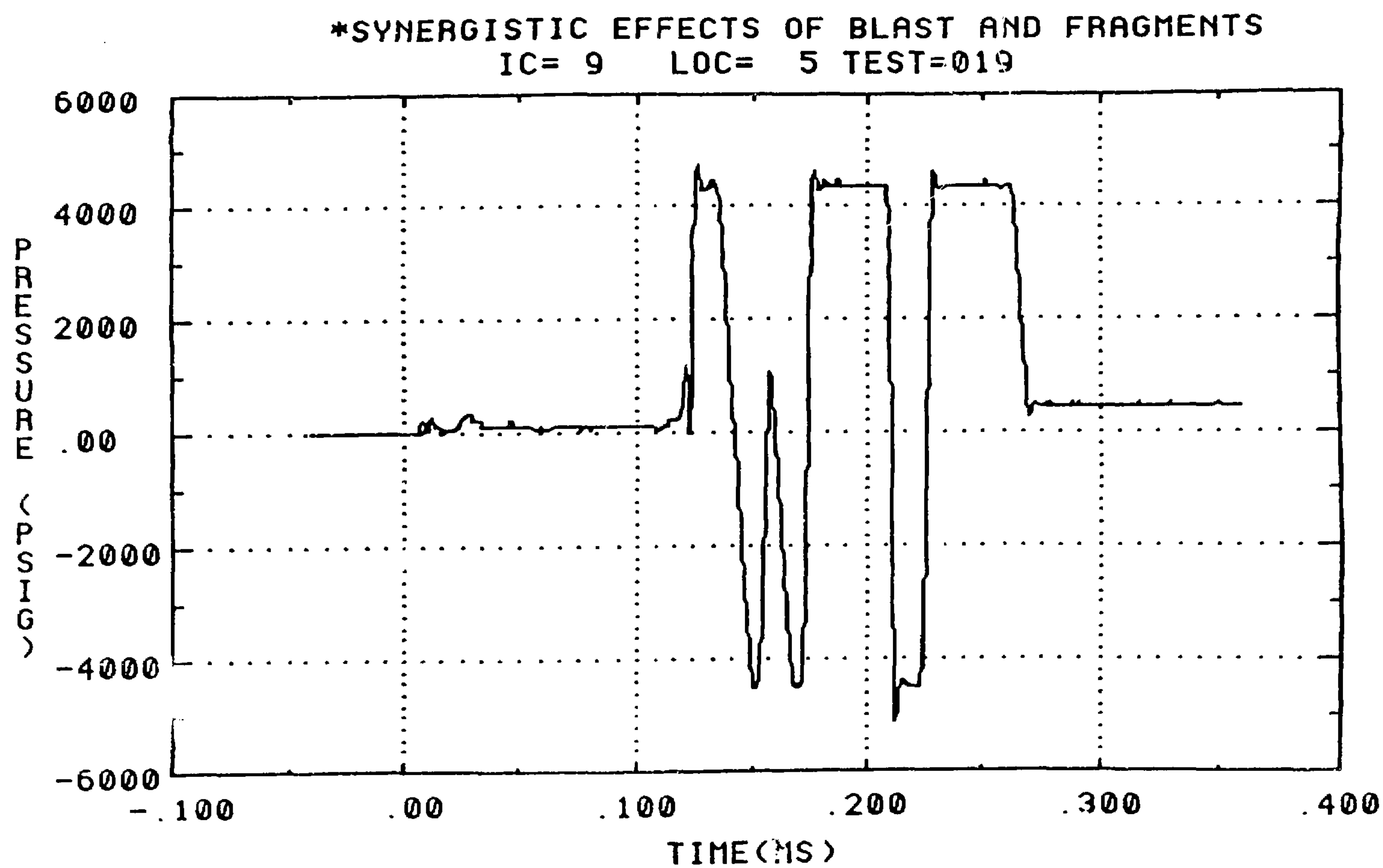


Figure C-51. Loads Test Data, Test 19, LOC 5

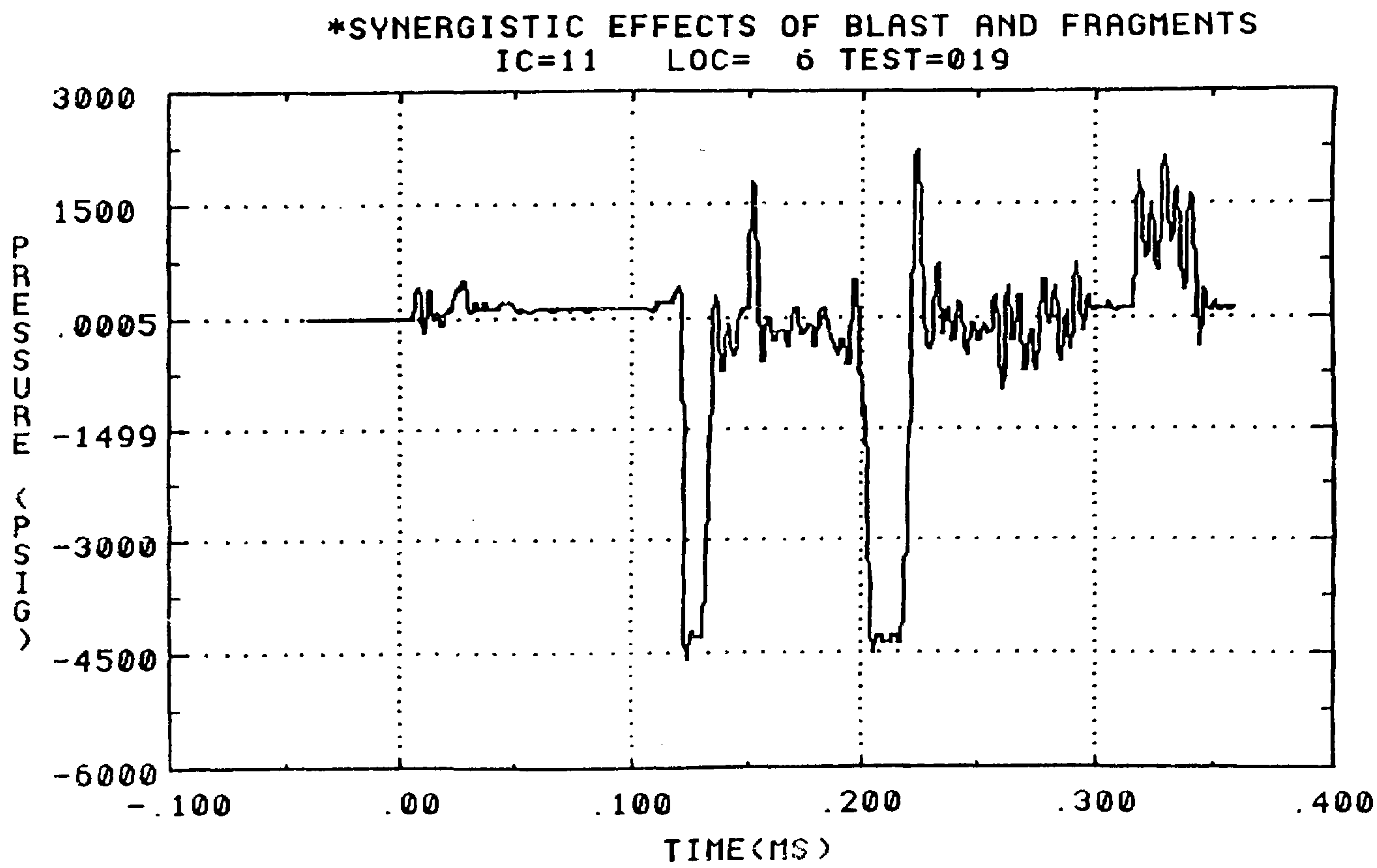


Figure C-52. Loads Test Data, Test 19, LOC 6

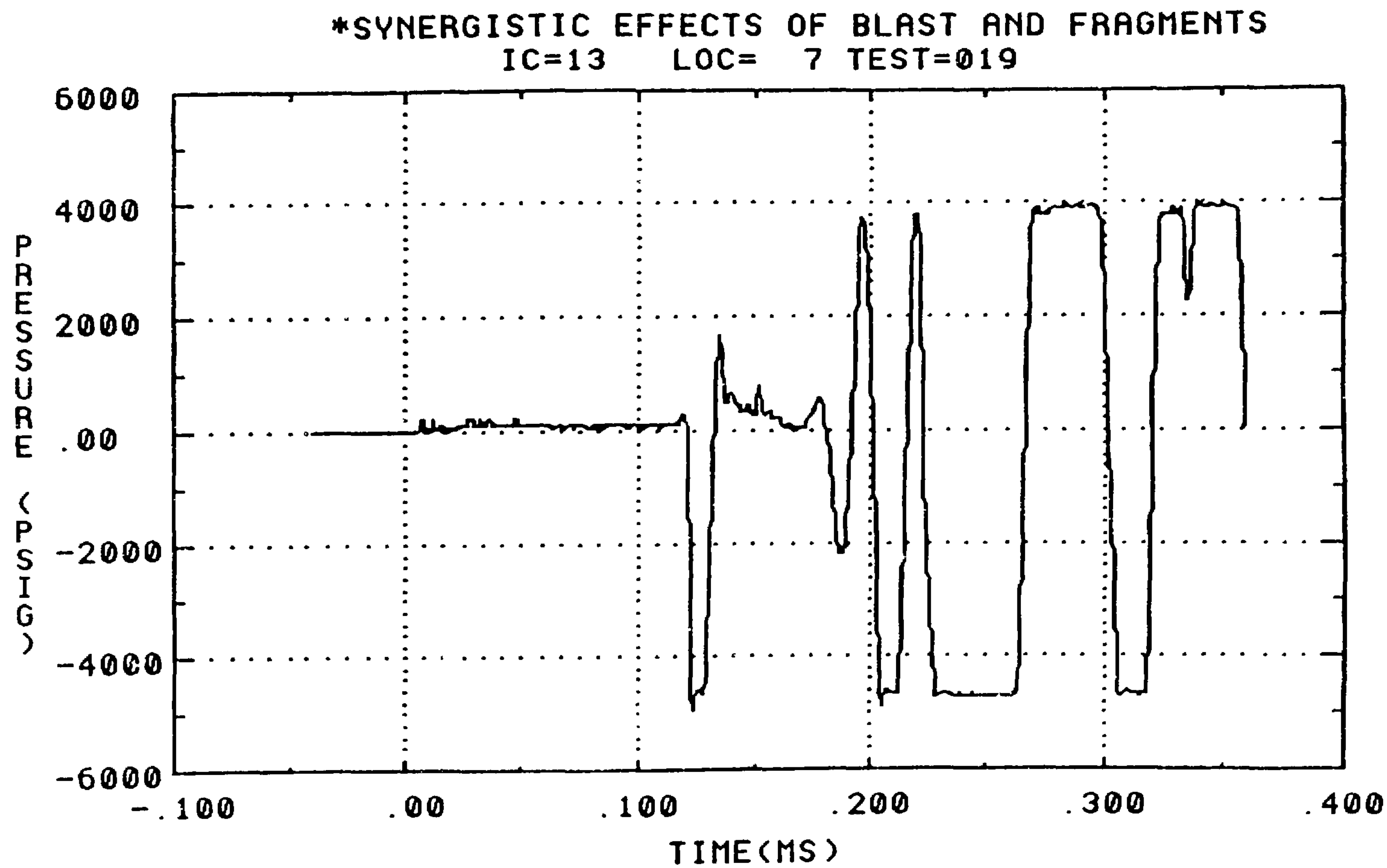


Figure C-53. Loads Test Data, Test 19, LOC 7

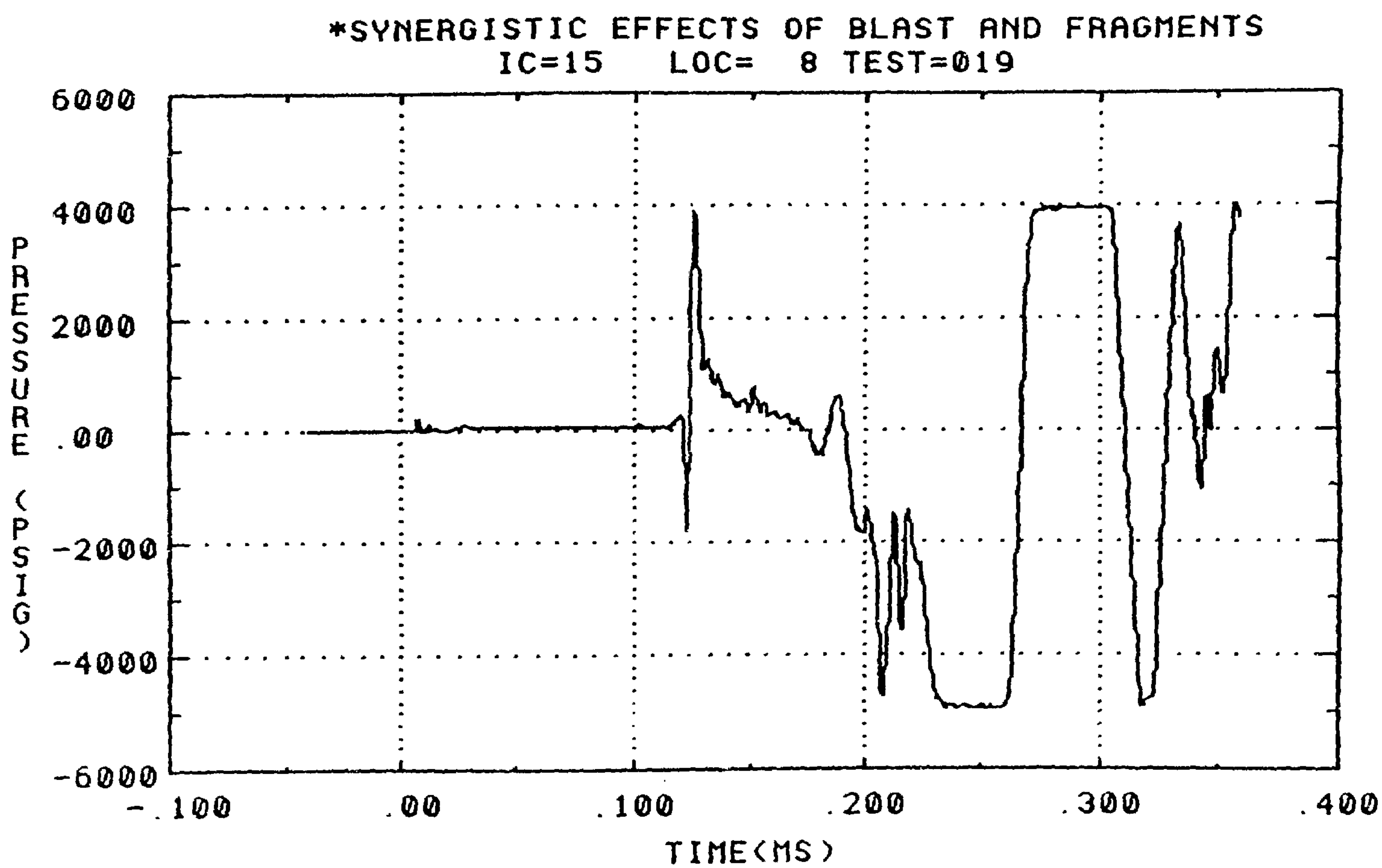


Figure C-54. Loads Test Data, Test 19, LOC 8

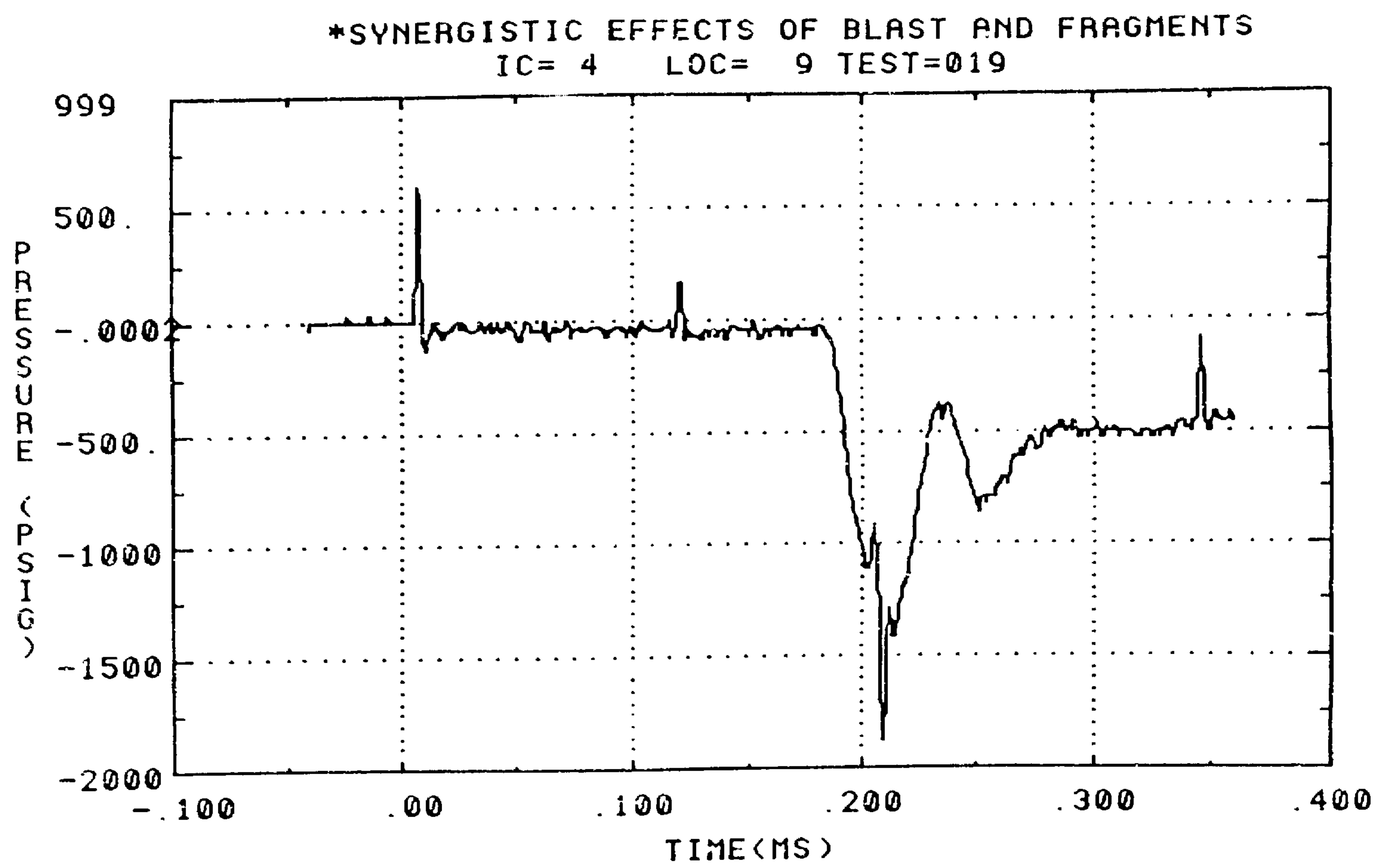


Figure C-55. Loads Test Data, Test 19, LOC 9

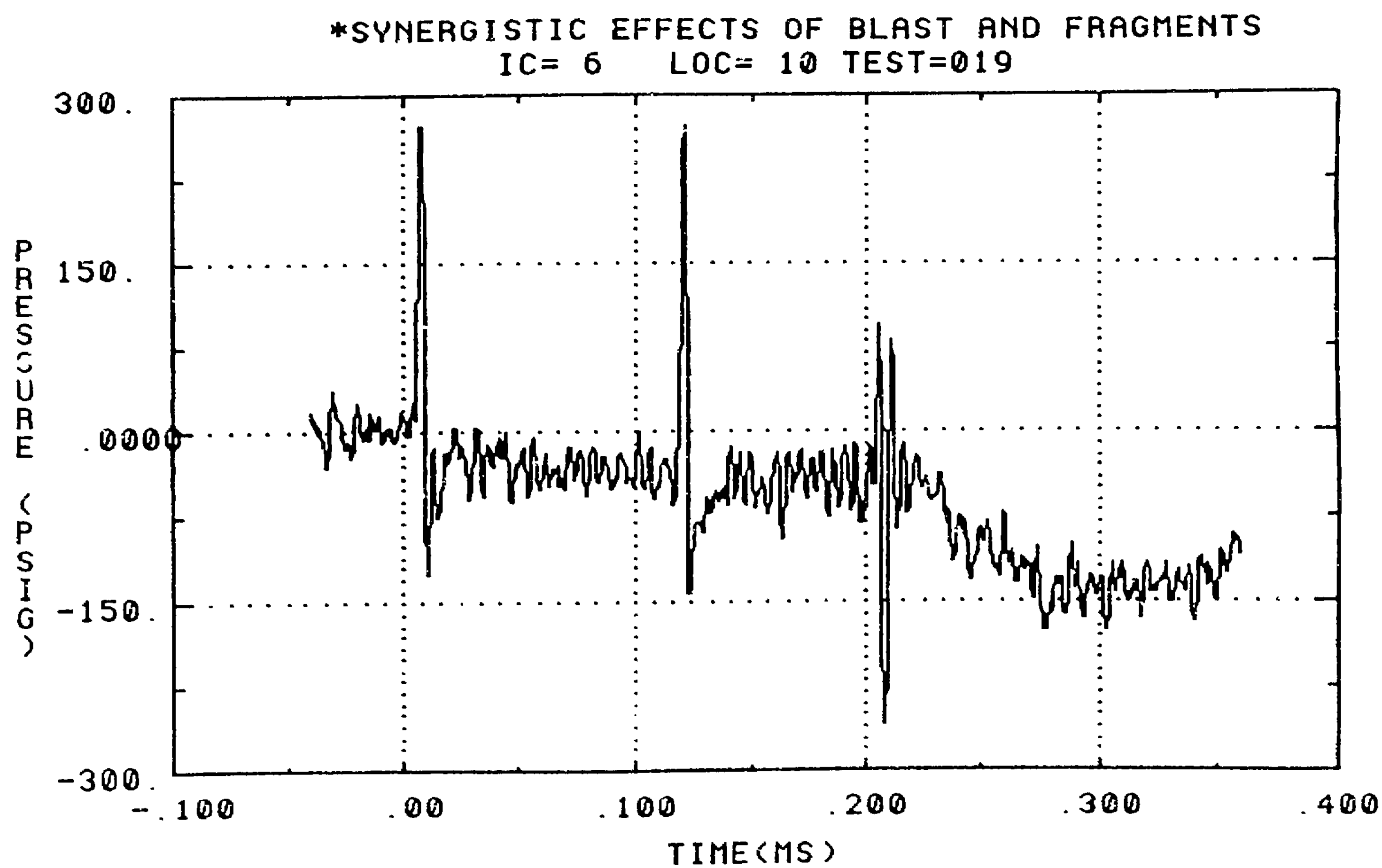


Figure C-56. Loads Test Data, Test 19, LOC 10

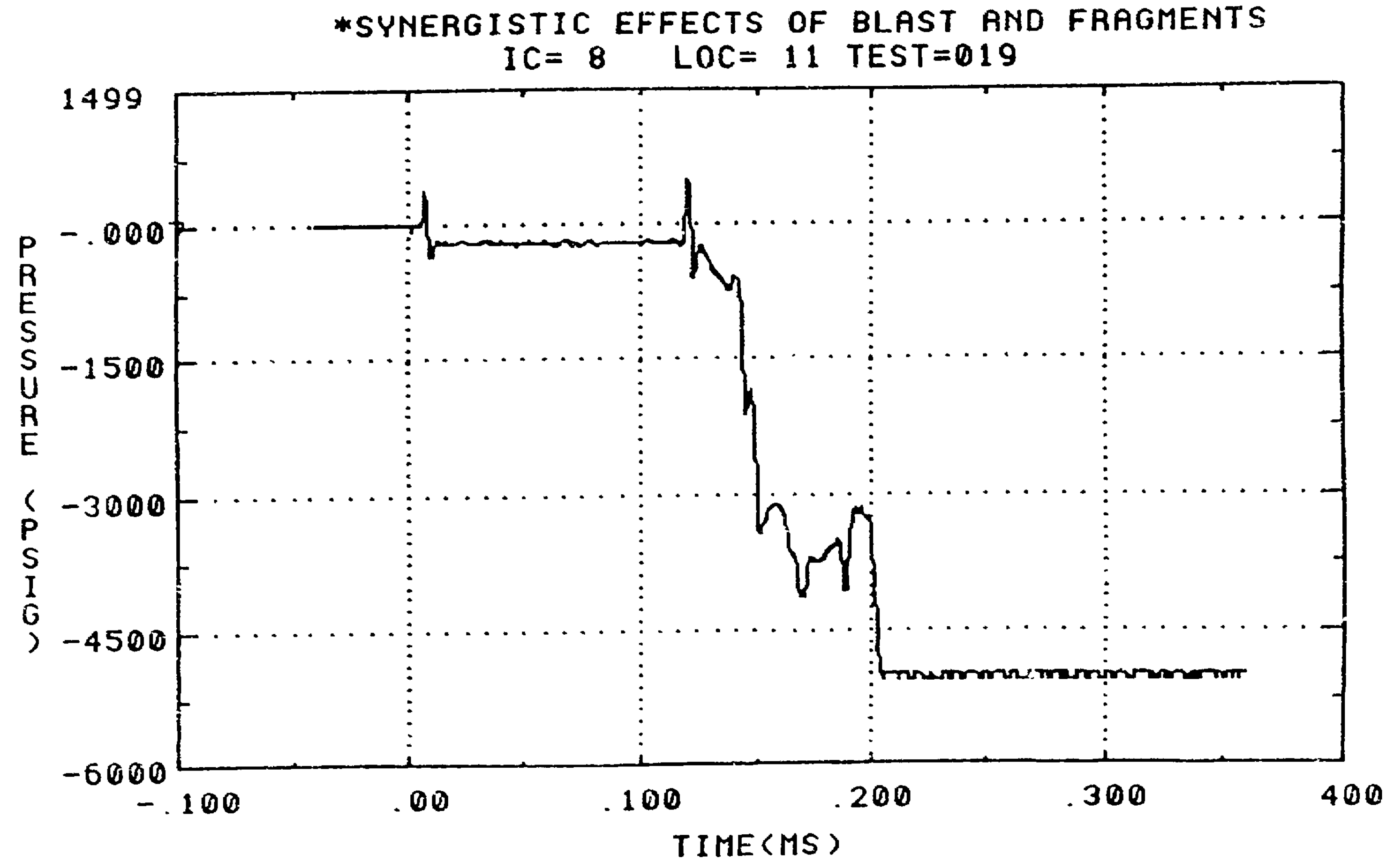


Figure C-57. Loads Test Data, Test 19, LOC 11

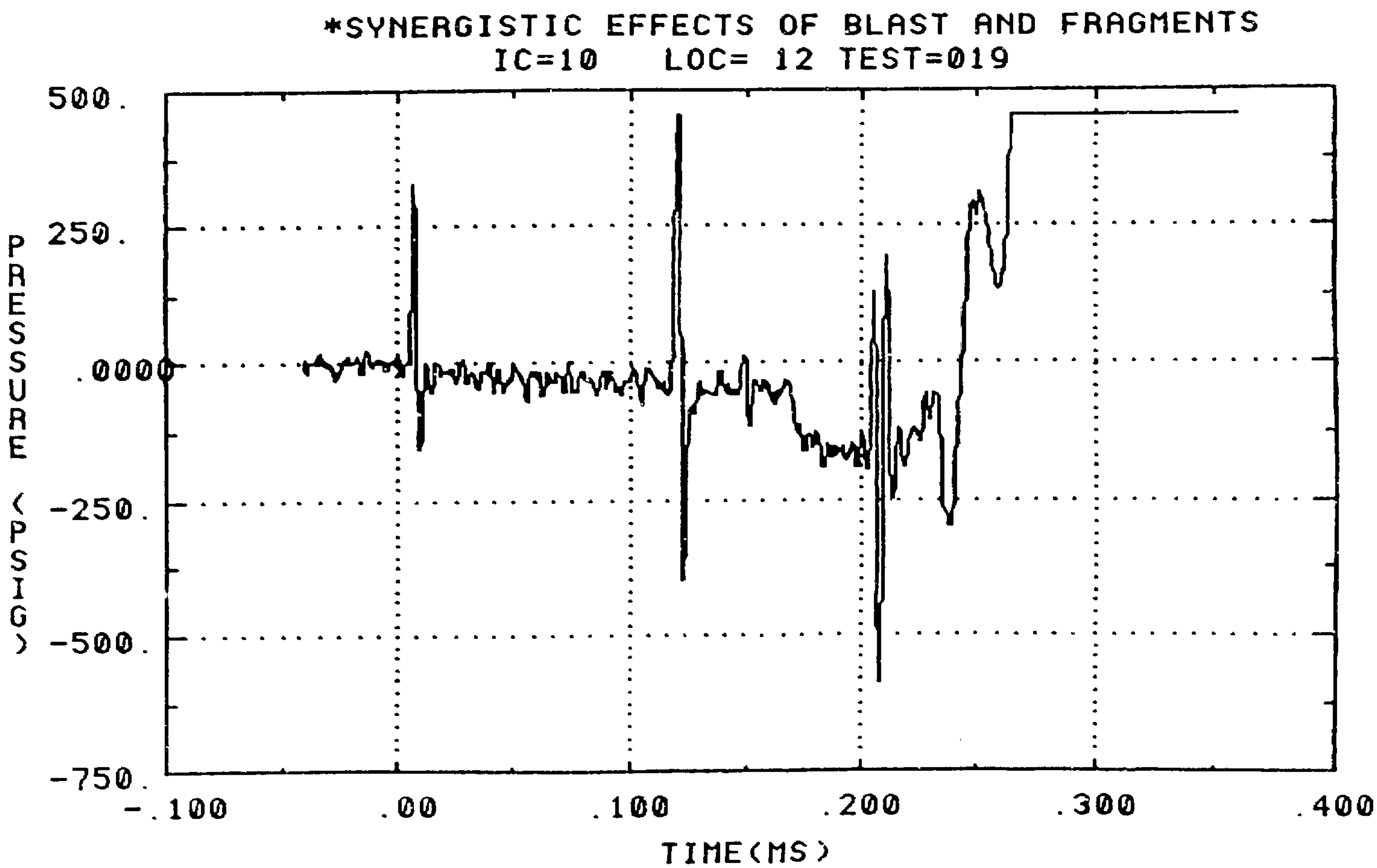


Figure C-58. Loads Test Data, Test 19, LOC 12

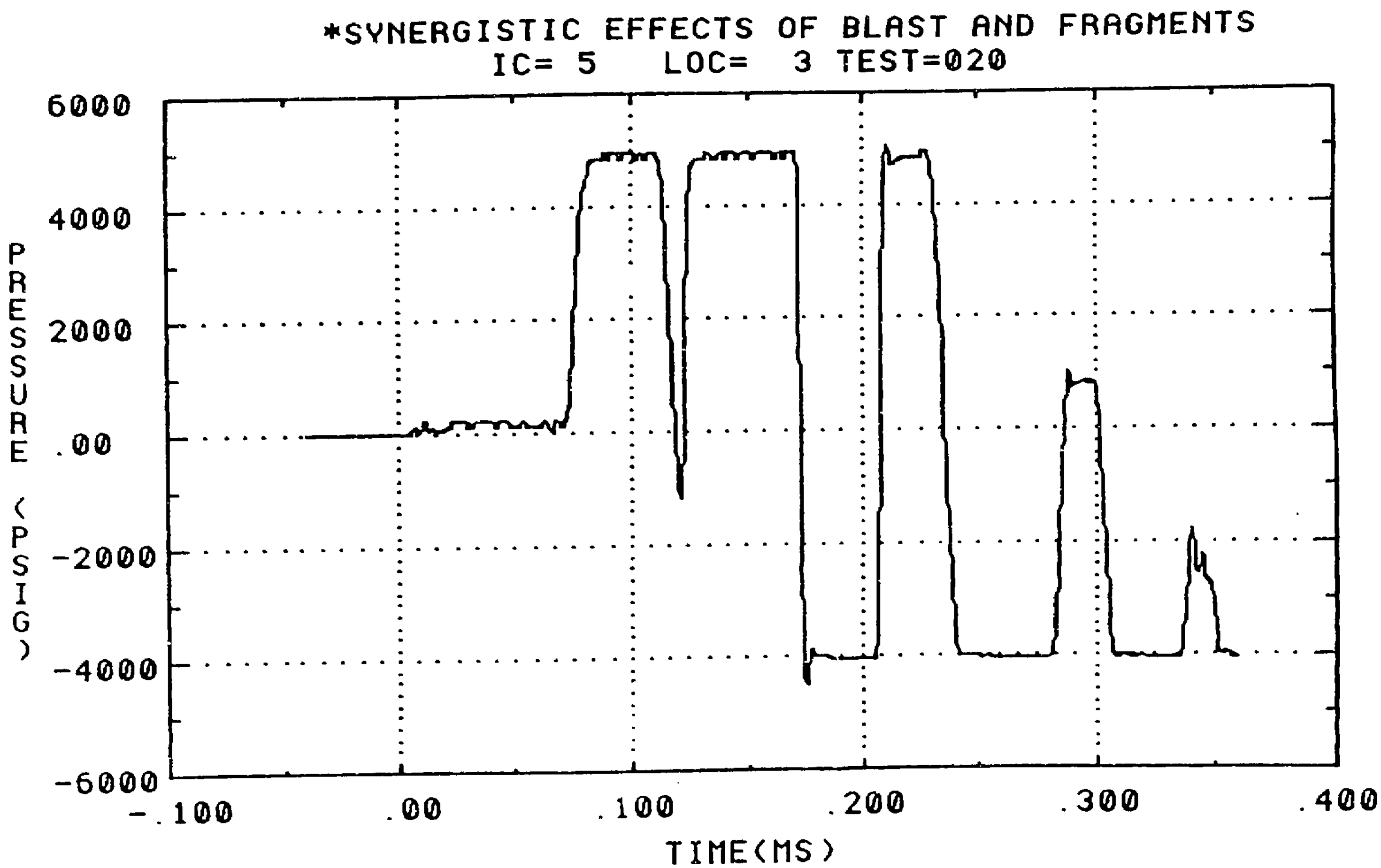


Figure C-59. Loads Test Data, Test 20, LOC 3

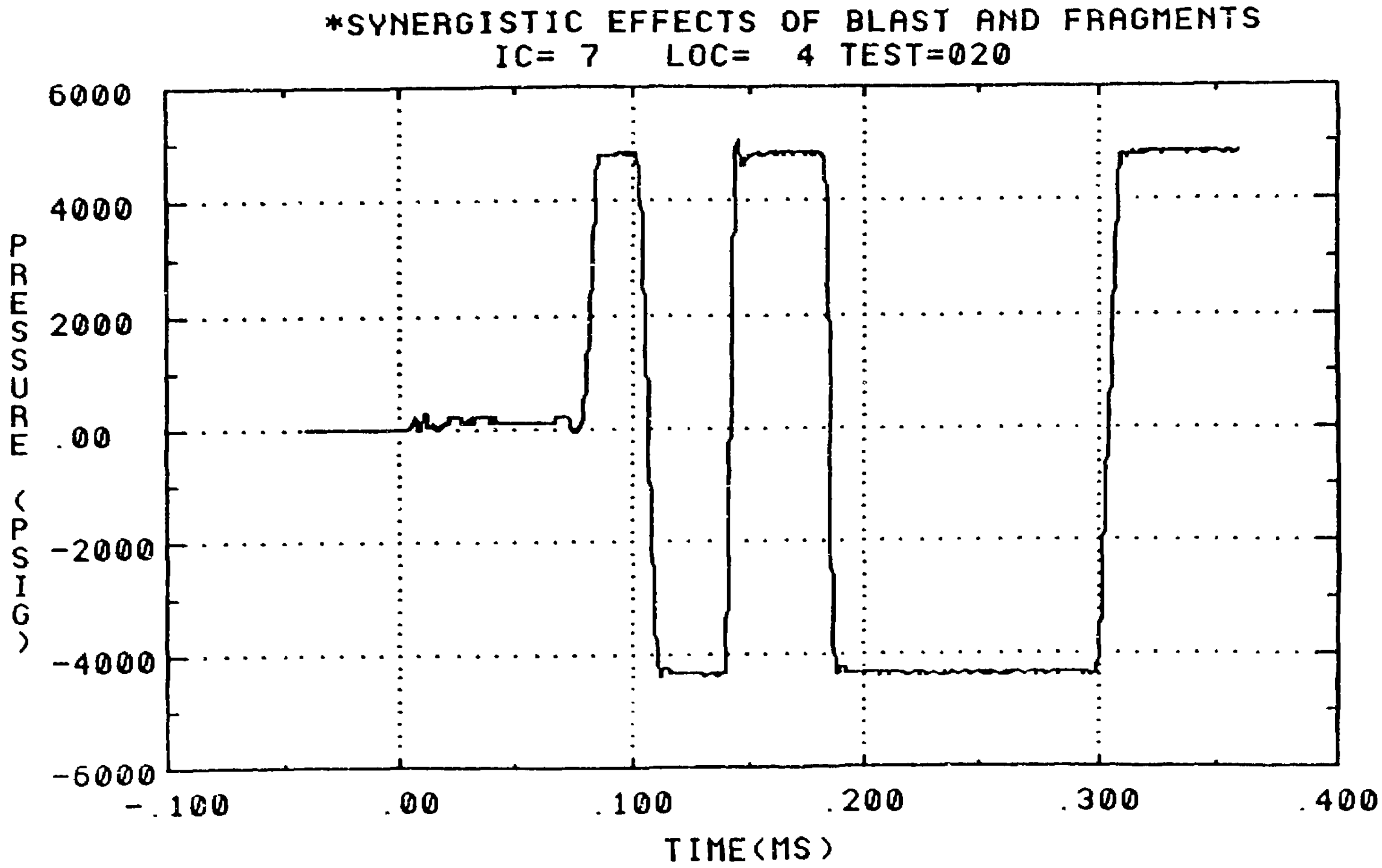


Figure C-60. Loads Test Data, Test 20, LOC 4

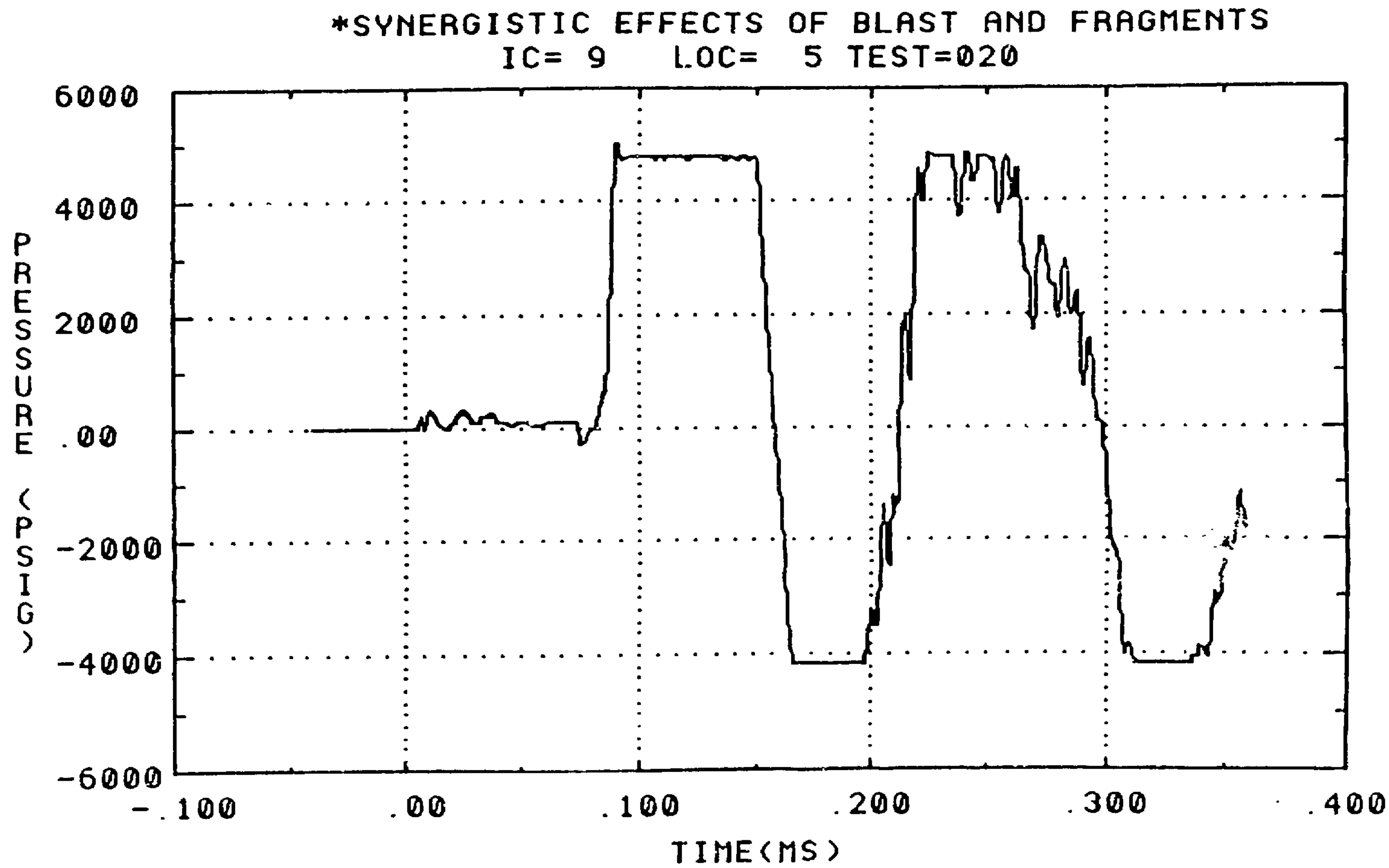


Figure C-61. Loads Test Data, Test 20, LOC 5

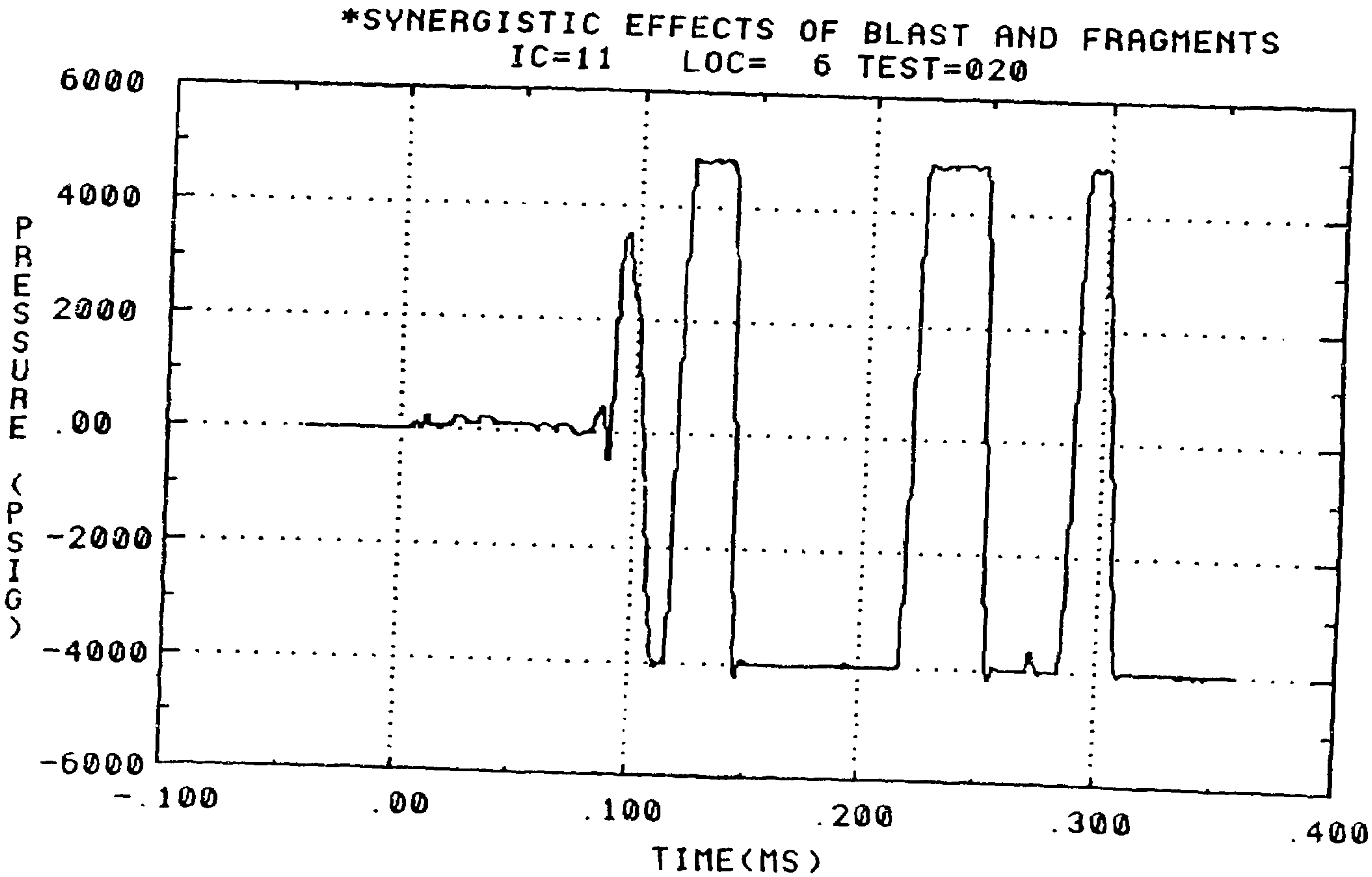


Figure C-62. Loads Test Data, Test 20, LOC 6

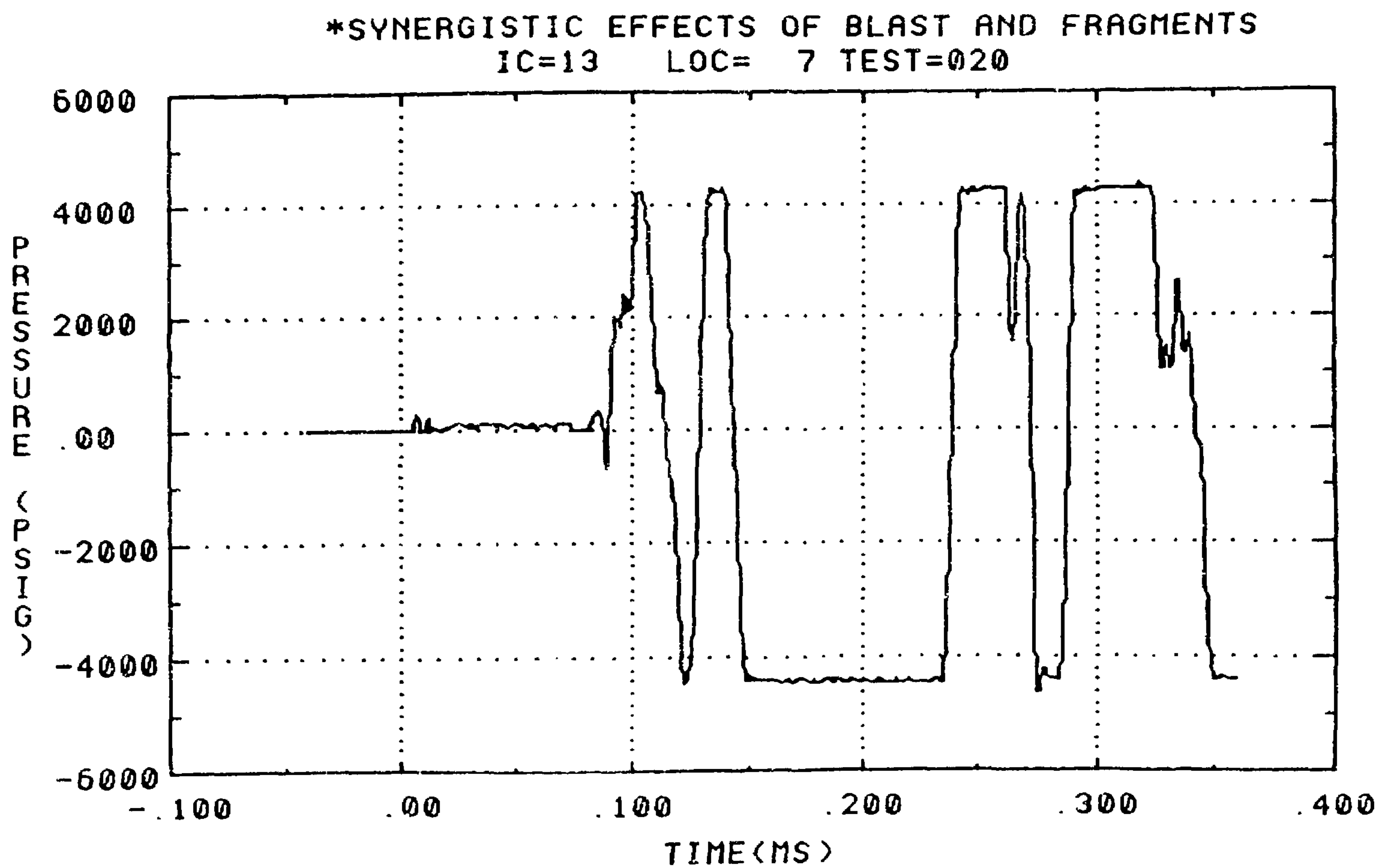


Figure C-63. Loads Test Data, Test 20, LOC 7

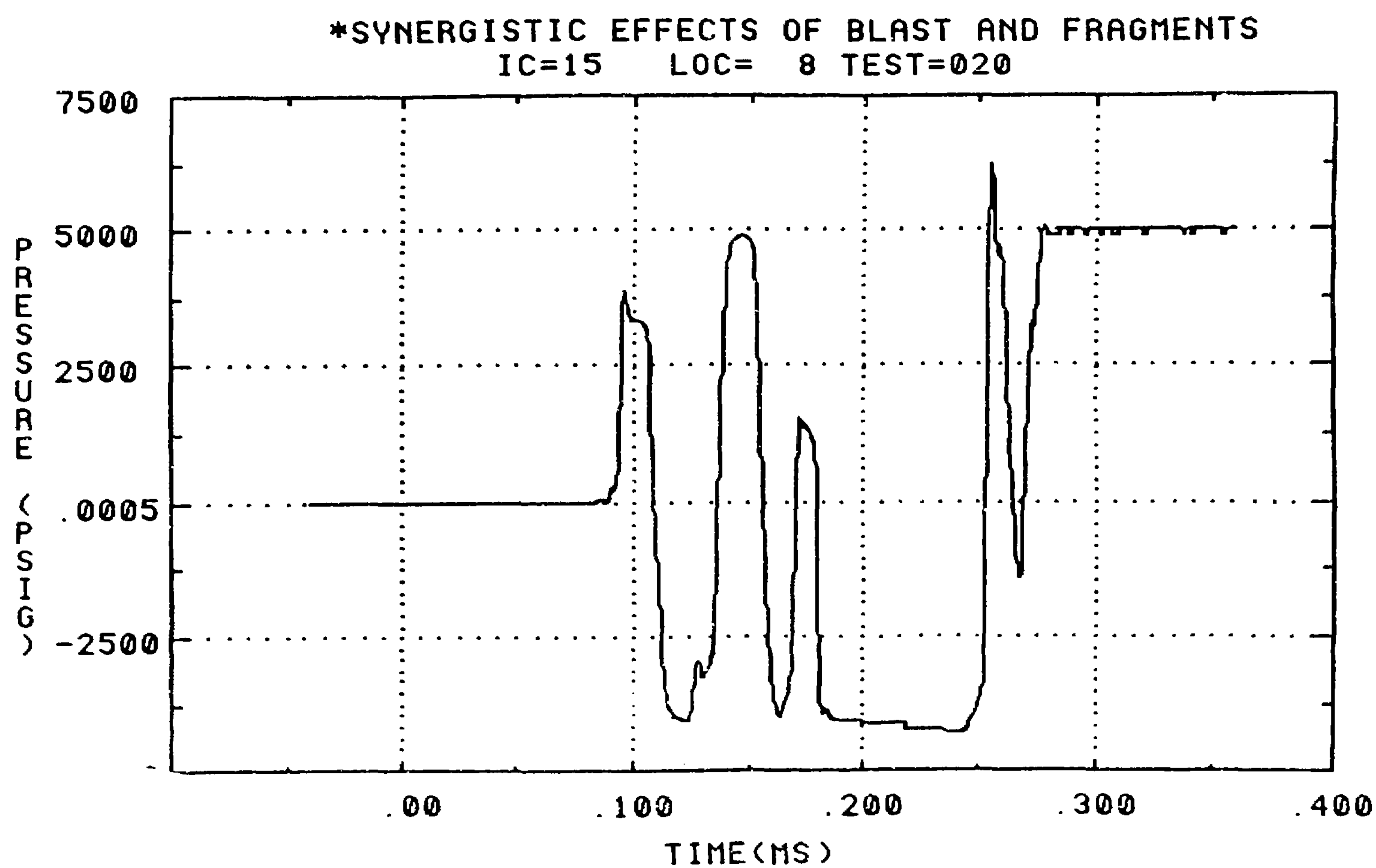


Figure C-64. Loads Test Data, Test 20, LOC 8

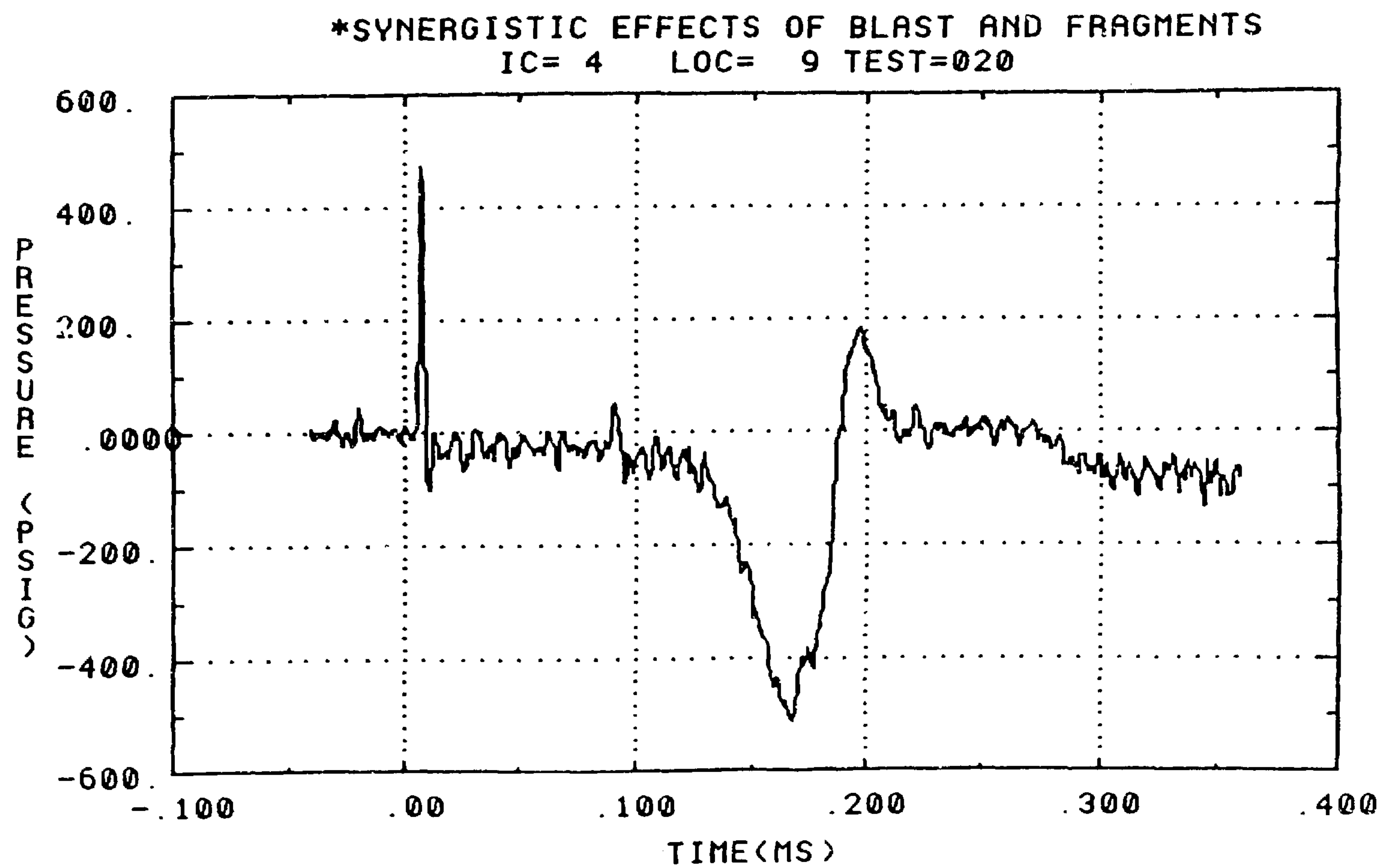


Figure C-65. Loads Test Data, Test 20, LOC 9

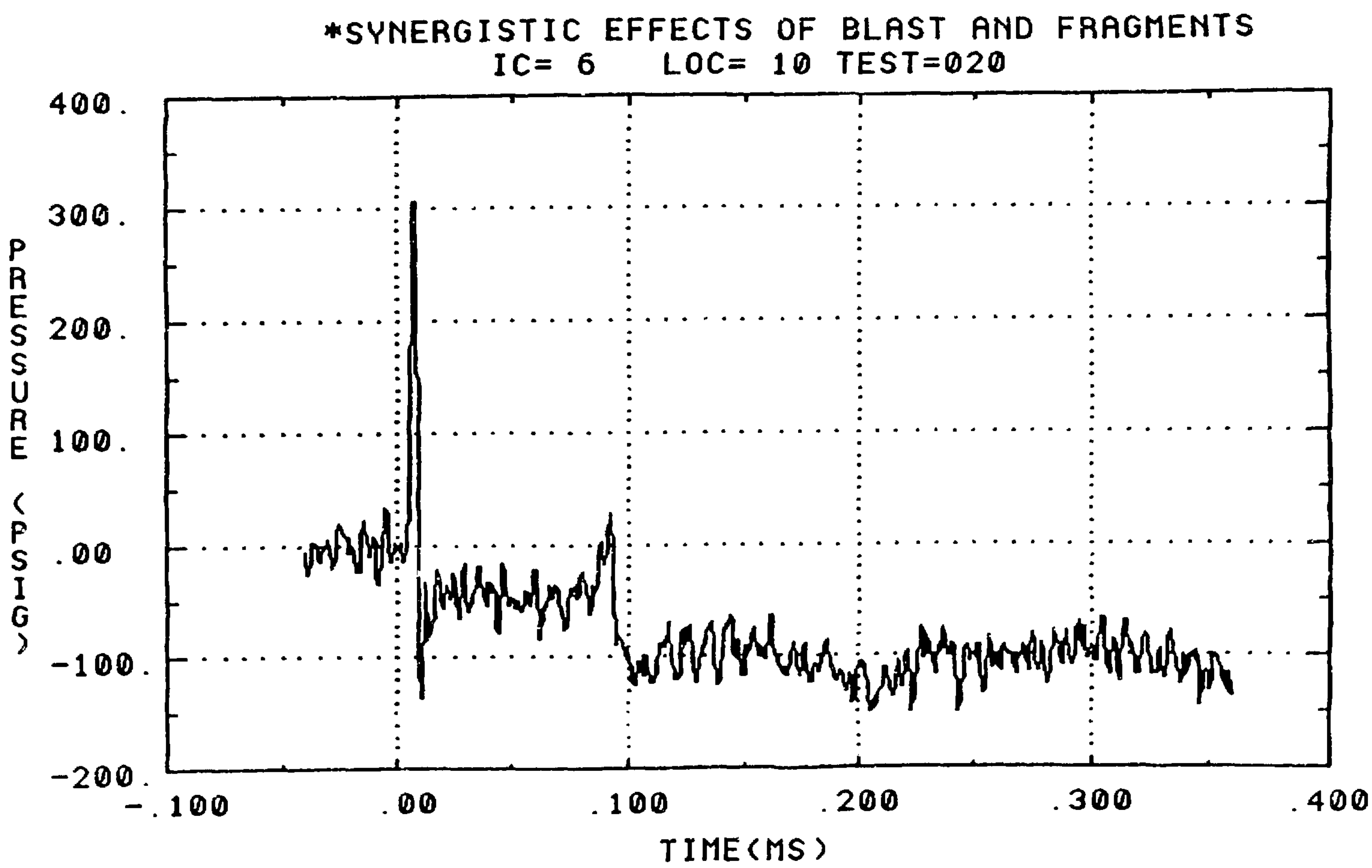


Figure C-66. Loads Test Data, Test 20, LOC 10

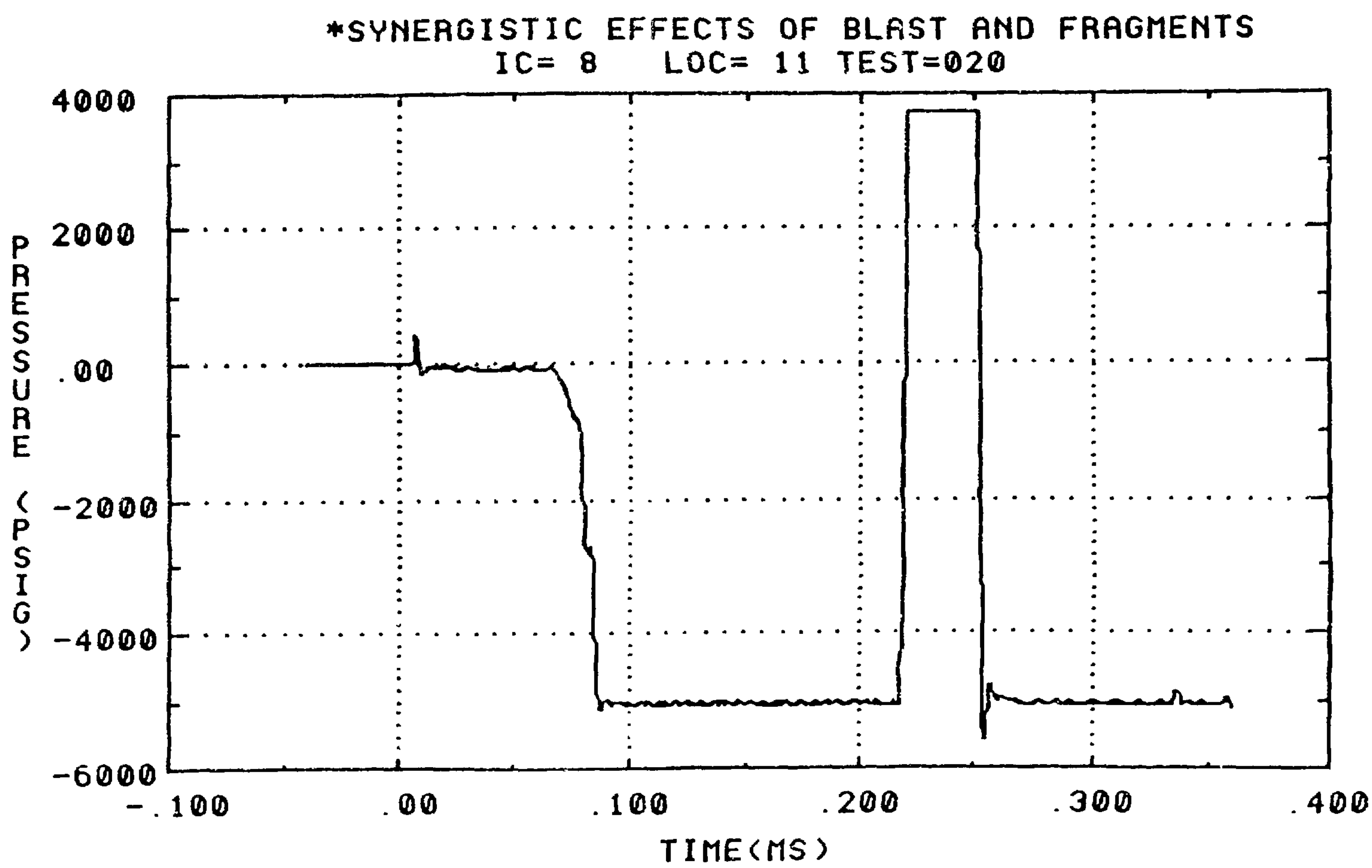


Figure C-67. Loads Test Data, Test 20, LOC 11

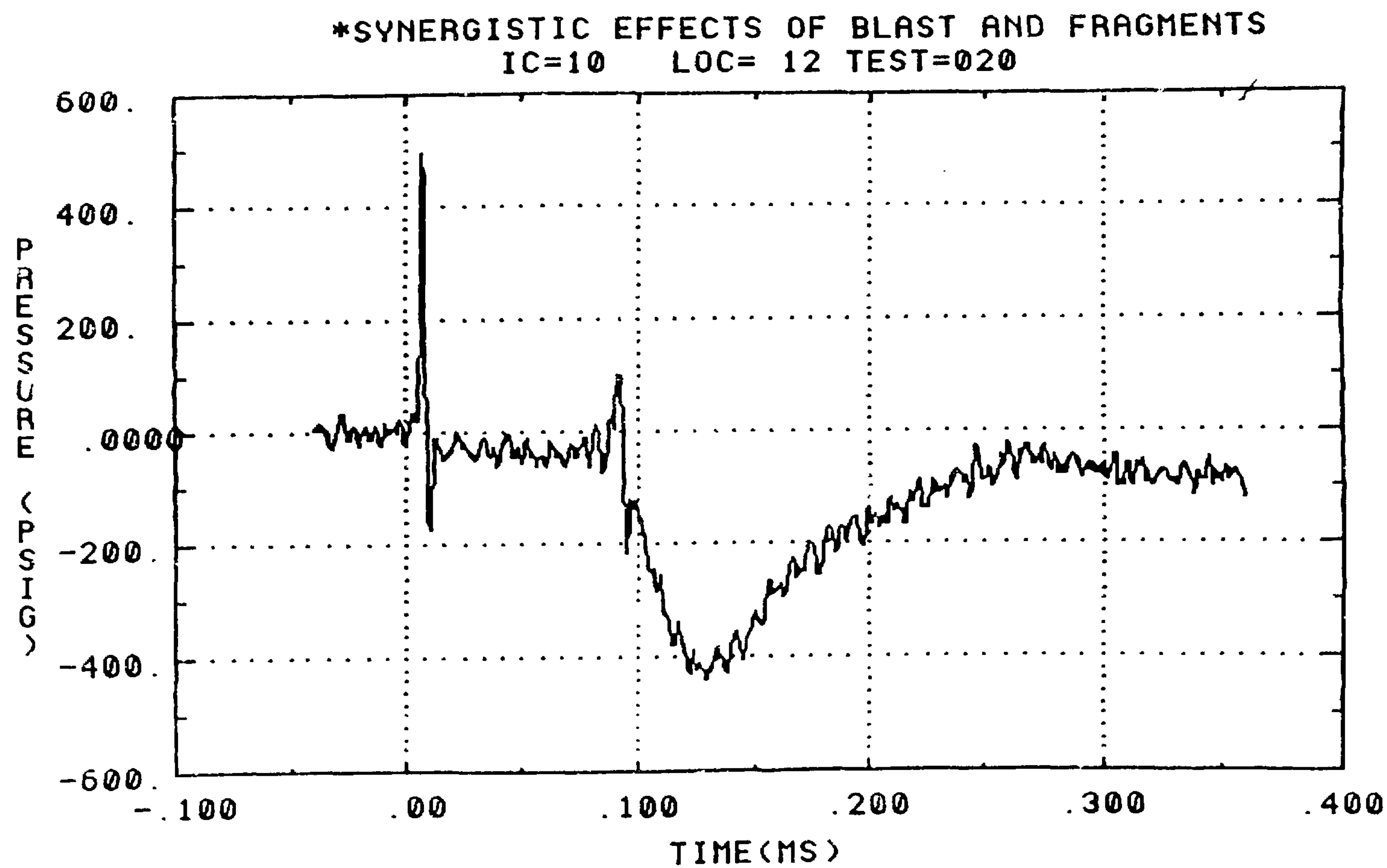


Figure C-68. Loads Test Data, Test 20, LOC 12

The Reverse of this page is blank

APPENDIX D

Dynasen Carbon Stress Gage Calibration Data

TABLE D-1. CARBON GAGE CALIBRATION DATA.

gage.dat

Wed, Mar 7, 1990 10 08

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
1	0.0000	0.0	0.0000	0.000	0.000	0.000	0.0000	0.000	0.0000
2	7250.0000	0.5	-279.2000	-300.000	-290.000	-307.000	-277.8000	-284.000	-286.8000
3	14500.0000	1.0	-537.2000	-568.000	-562.000	-582.000	-544.8000	-548.000	-560.8000
4	21750.0000	1.5	-729.2000	-788.000	-786.000	-810.000	-760.8000	-776.000	-772.8000
5	29000.0000	2.0	-961.2000	-1028.000	-1028.000	-1046.000	-992.8000	-996.000	-1008.8000
6	36250.0000	2.5	-1161.2000	-1220.000	-1234.000	-1278.000	-1192.8000	-1196.000	-1216.8000
7	43500.0000	3.0	-1361.2000	-1436.000	-1442.000	-1470.000	-1384.8000	-1388.000	-1416.8000
8	50750.0000	3.5	-1553.2000	-1620.000	-1634.000	-1662.000	-1576.8000	-1588.000	-1624.8000
9	58000.0000	4.0	-1729.2000	-1804.000	-1810.000	-1862.000	-1744.8000	-1748.000	-1776.8000
10	65250.0000	4.5	-1897.2000	-1972.000	-2010.000	-2038.000	-1904.8000	-1924.000	-1984.8000
11	72500.0000	5.0	-2033.2000	-2148.000	-2170.000	-2214.000	-2096.8000	-2084.000	-2144.8000
12	79750.0000	5.5	-2193.2000	-2308.000	-2362.000	-2390.000	-2256.8000	-2292.000	-2336.8000
13	87000.0000	6.0	-2353.2000	-2468.000	-2506.000	-2566.000	-2432.8000	-2420.000	-2496.8000
14	94250.0000	6.5	-2513.2000	-2660.000	-2682.000	-2726.000	-2592.8000	-2580.000	-2656.8000
15	101500.0000	7.0	-2689.2000	-2820.000	-2858.000	-2918.000	-2752.8000	-2772.000	-2832.8000
16	108750.0000	7.5	-2849.2000	-2980.000	-3018.000	-3078.000	-2912.8000	-2932.000	-2960.8000

TABLE D-1. CARBON GAGE CALIBRATION DATA (CONTINUED).

gage.dat

Wed, Mar 7, 1990 10.08

	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18
1	0.0000	0.0000	0.000	0.000	0.000	0.000	0.0000	0.000	0.000
2	-301.2000	-329.6000	-341.000	-333.000	-324.000	-308.000	-318.6000	-326.000	-327.000
3	-573.2000	-629.6000	-648.000	-639.000	-641.000	-582.000	-609.6000	-616.000	-618.000
4	-793.2000	-881.6000	-904.000	-891.000	-913.000	-818.000	-849.6000	-852.000	-866.000
5	-1029.2000	-1145.6000	-1176.000	-1163.000	-1177.000	-1062.000	-1073.6000	-1100.000	-1122.000
6	-1253.2000	-1377.6000	-1408.000	-1403.000	-1417.000	-1282.000	-1321.6000	-1340.000	-1354.000
7	-1453.2000	-1609.6000	-1540.000	-1627.000	-1657.000	-1498.000	-1529.6000	-1548.000	-1554.000
8	-1637.2000	-1833.6000	-1848.000	-1843.000	-1905.000	-1690.000	-1729.6000	-1772.000	-1786.000
9	-1829.2000	-2057.6000	-2072.000	-2099.000	-2129.000	-1398.000	-1921.6000	-1956.000	-1986.000
10	-2005.2000	-2249.6000	-2280.000	-2275.000	-2305.000	-2090.000	-2145.6000	-2188.000	-2162.000
11	-2197.2000	-2425.6000	-2456.000	-2451.000	-2497.000	-2234.000	-2305.6000	-2348.000	-2354.000
12	-2373.2000	-2617.6000	-2664.000	-2659.000	-2721.000	-2426.000	-2513.6000	-2524.000	-2546.000
13	-2533.2000	-2808.6000	-2840.000	-2851.000	-2881.000	-2586.000	-2641.6000	-2716.000	-2706.000
14	-2693.2000	-3001.6000	-3016.000	-3043.000	-3105.000	-2810.000	-2865.6000	-2908.000	-2898.000
15	-2885.2000	-3209.6000	-3240.000	-3251.000	-3281.000	-2954.000	-3057.6000	-3068.000	-3122.000
16	-3045.2000	-3401.6000	-3416.000	-3443.000	-3473.000	-3114.000	-3201.6000	-3276.000	-3298.000

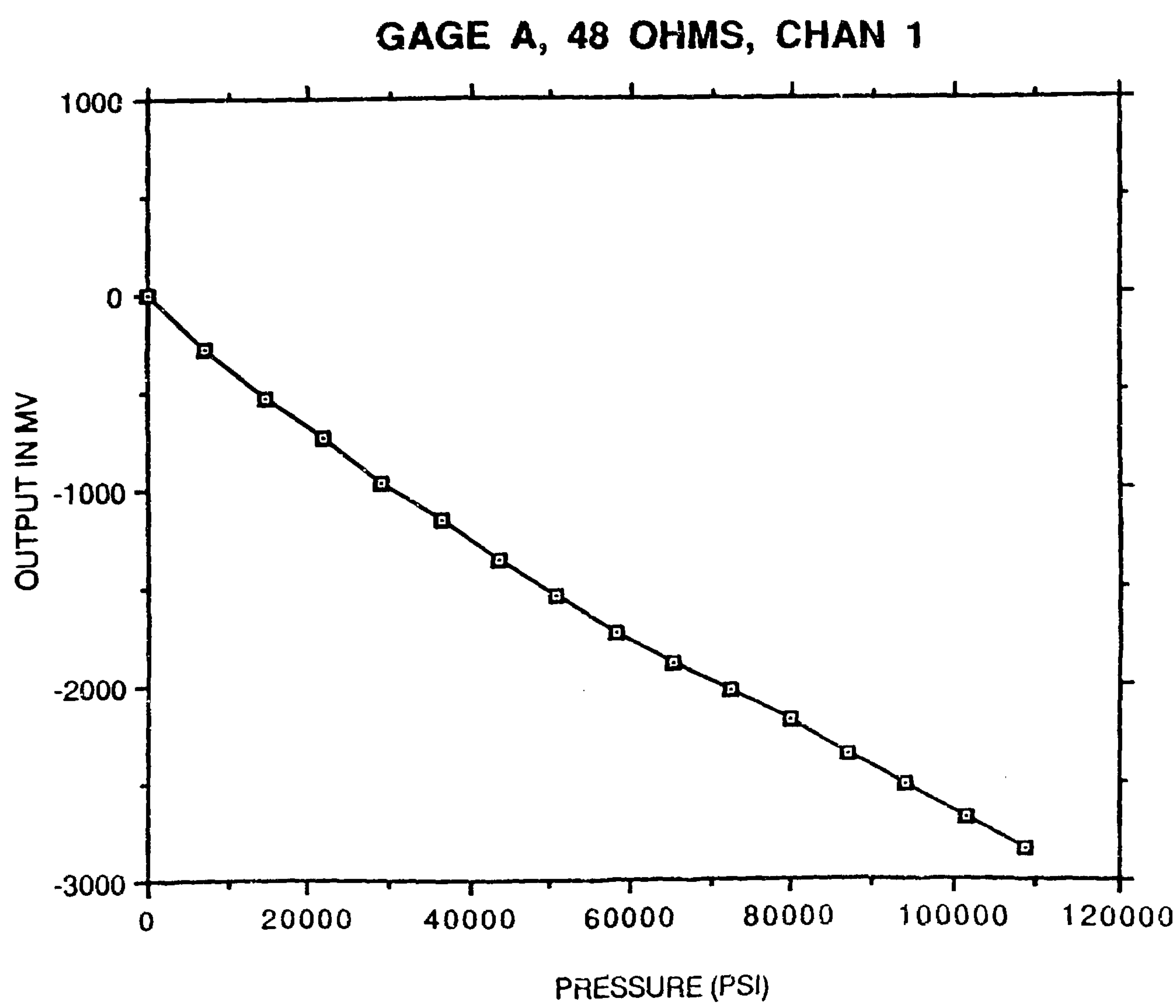


Figure D-1. Gage Calibration Curve.

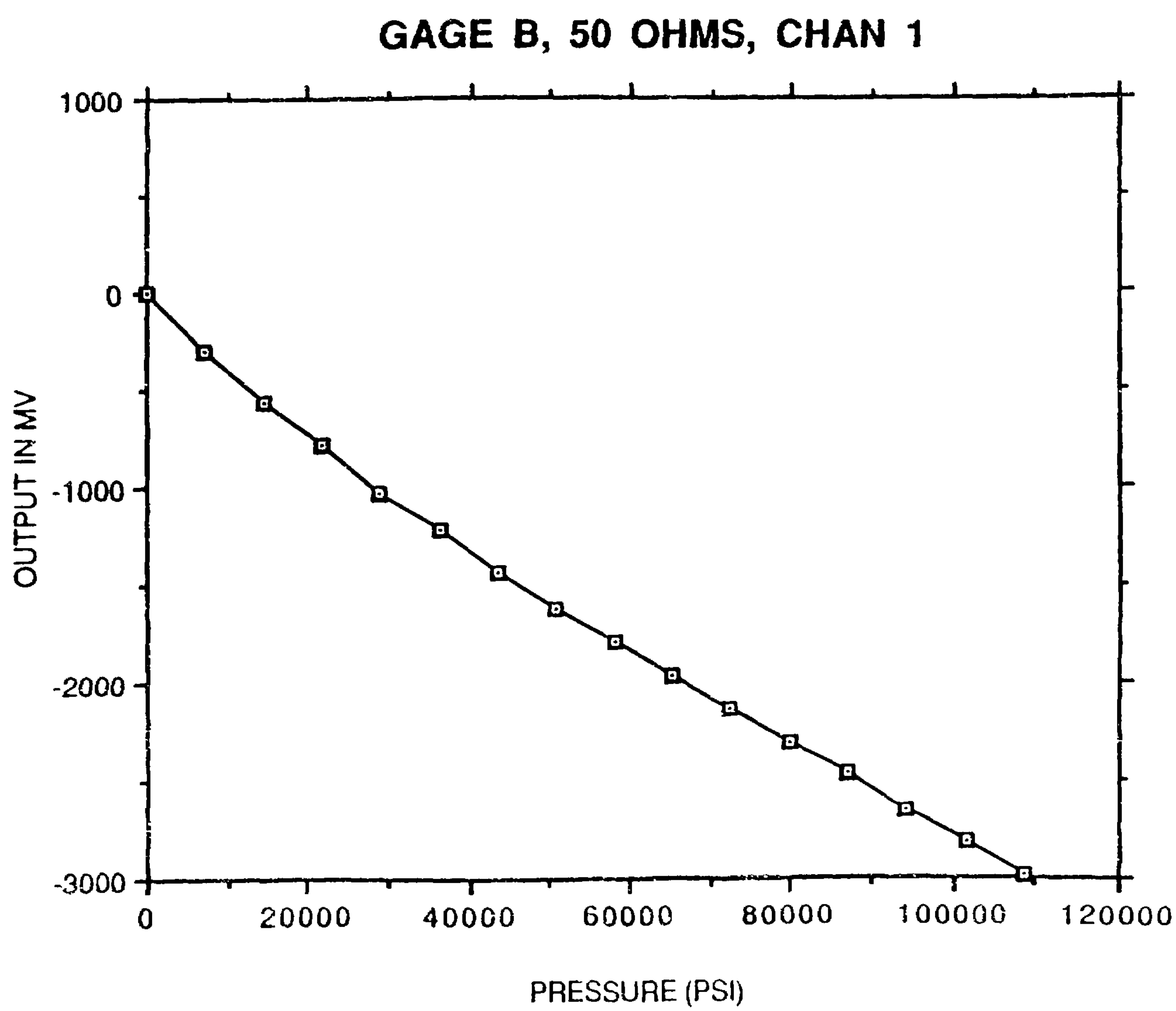


Figure D-2. Gage Calibration Curve.

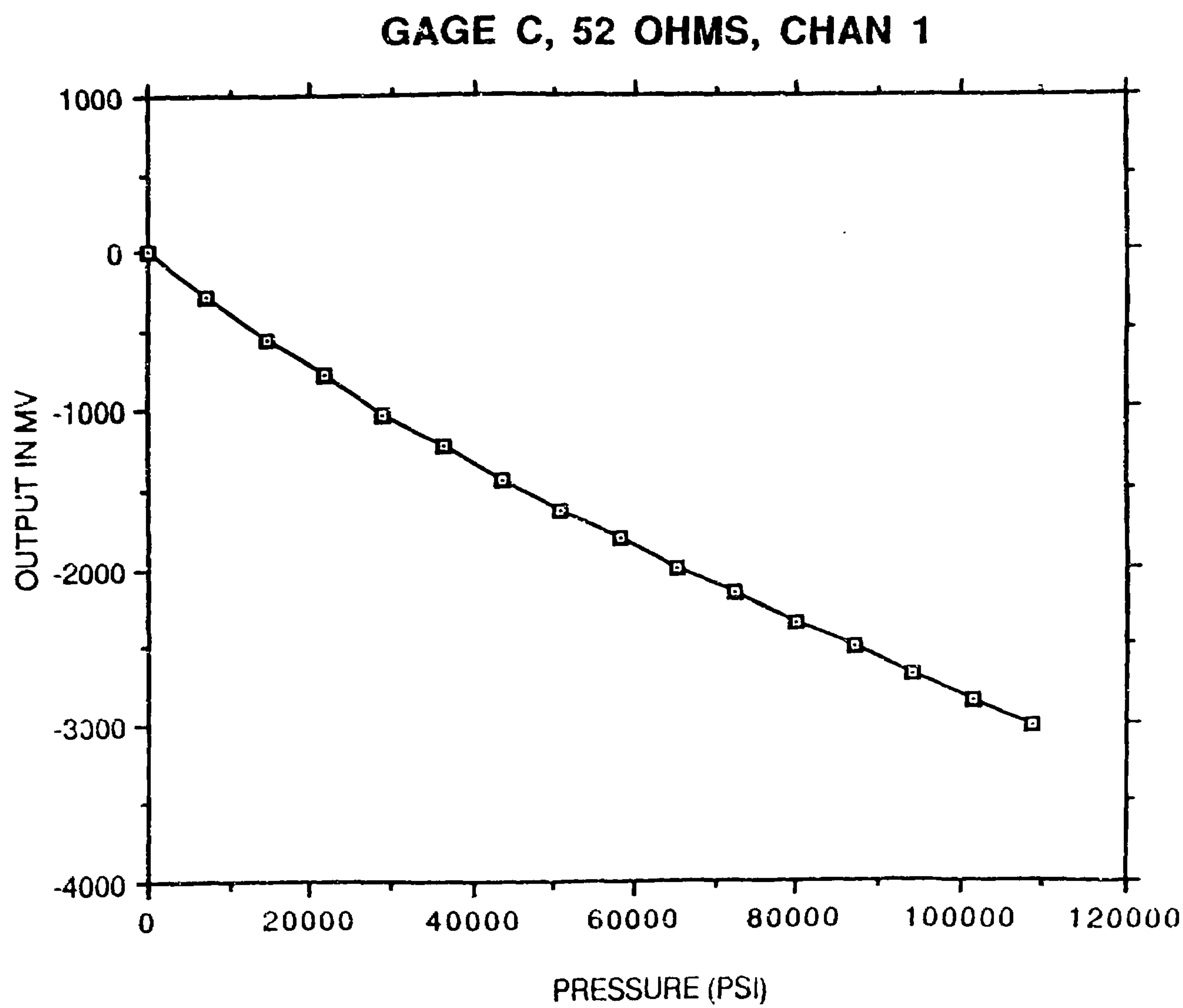


Figure D-3. Gage Calibration Curve.

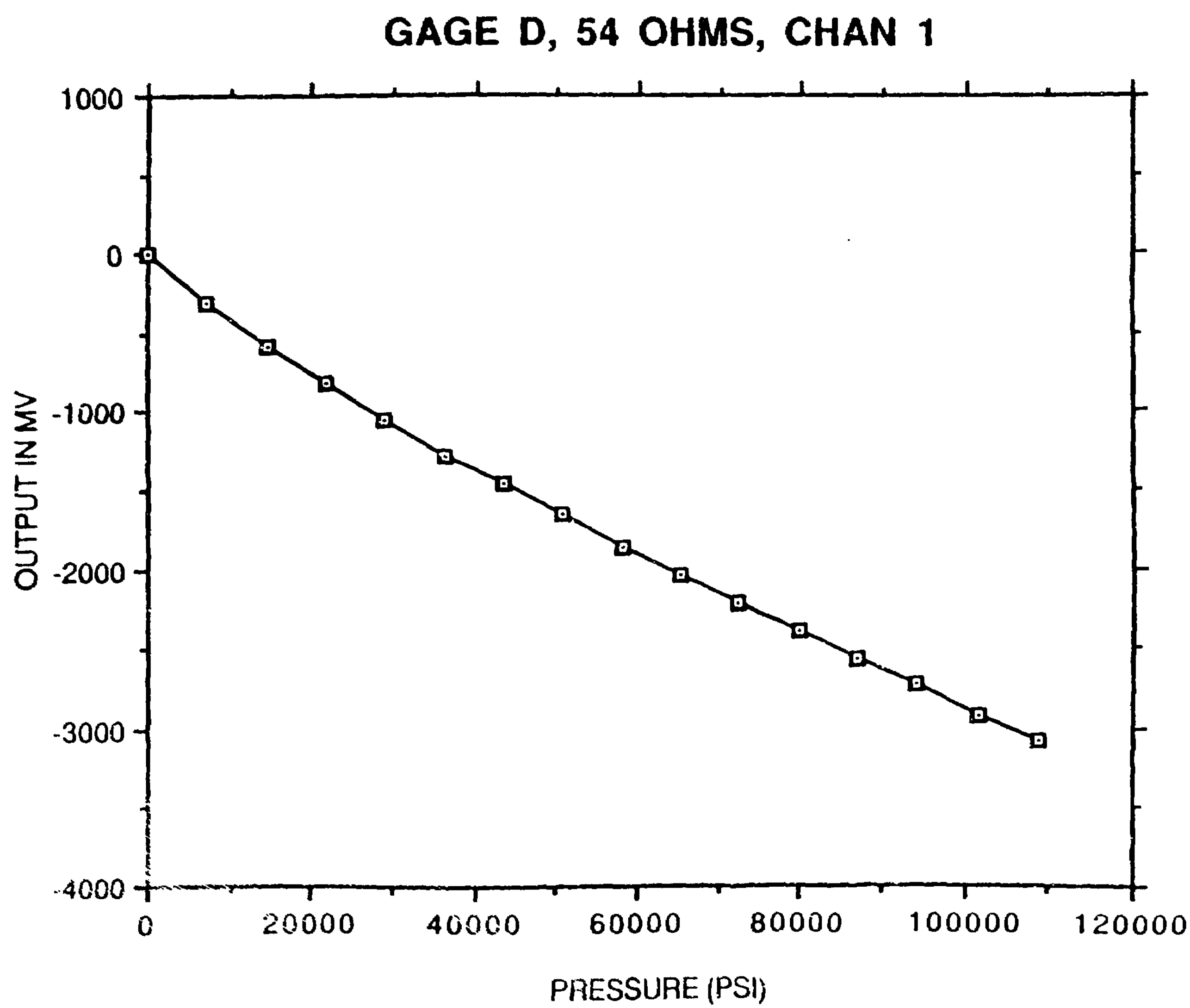


Figure D-4. Gage Calibration Curve.

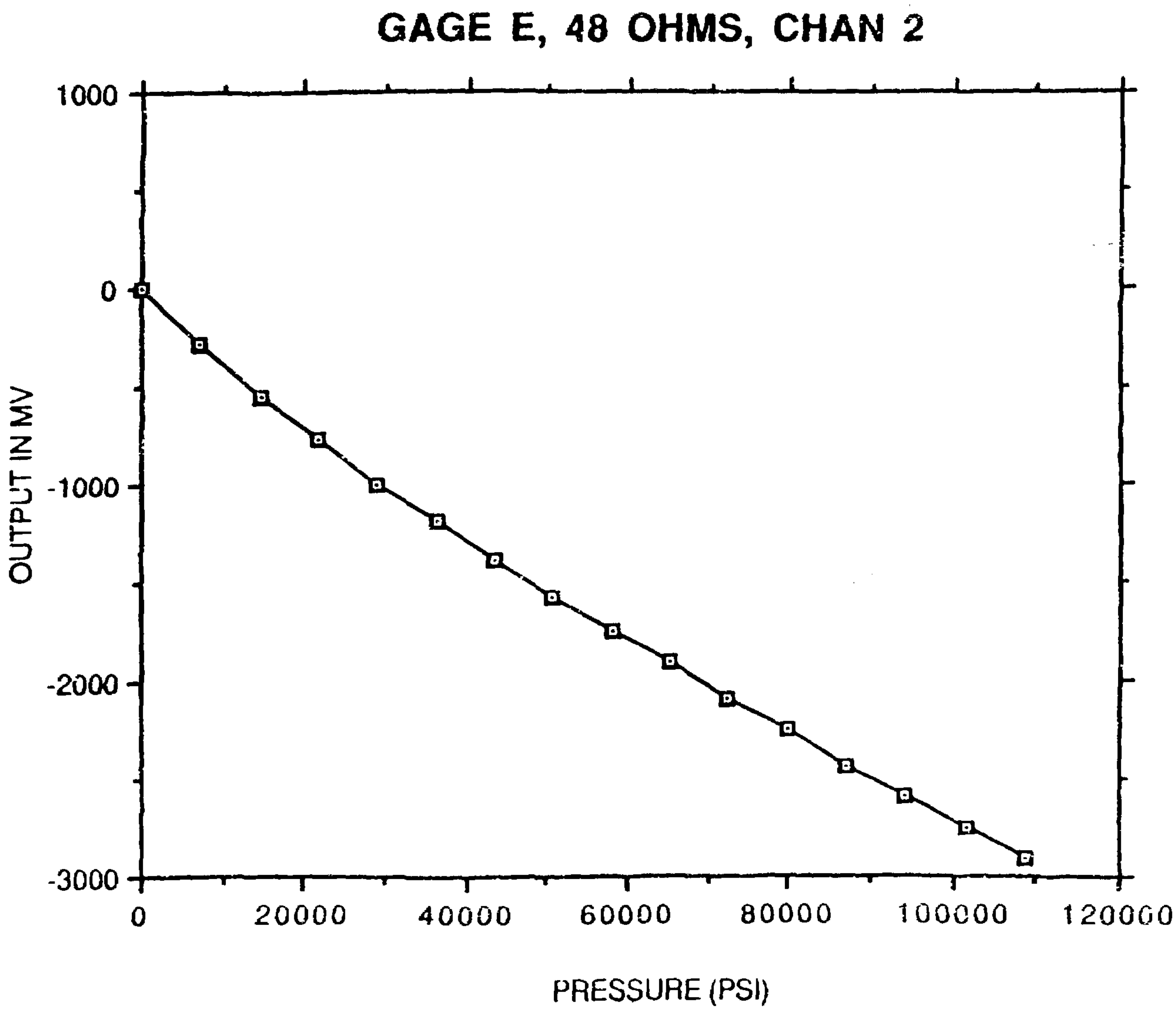


Figure D-5. Gage Calibration Curve.

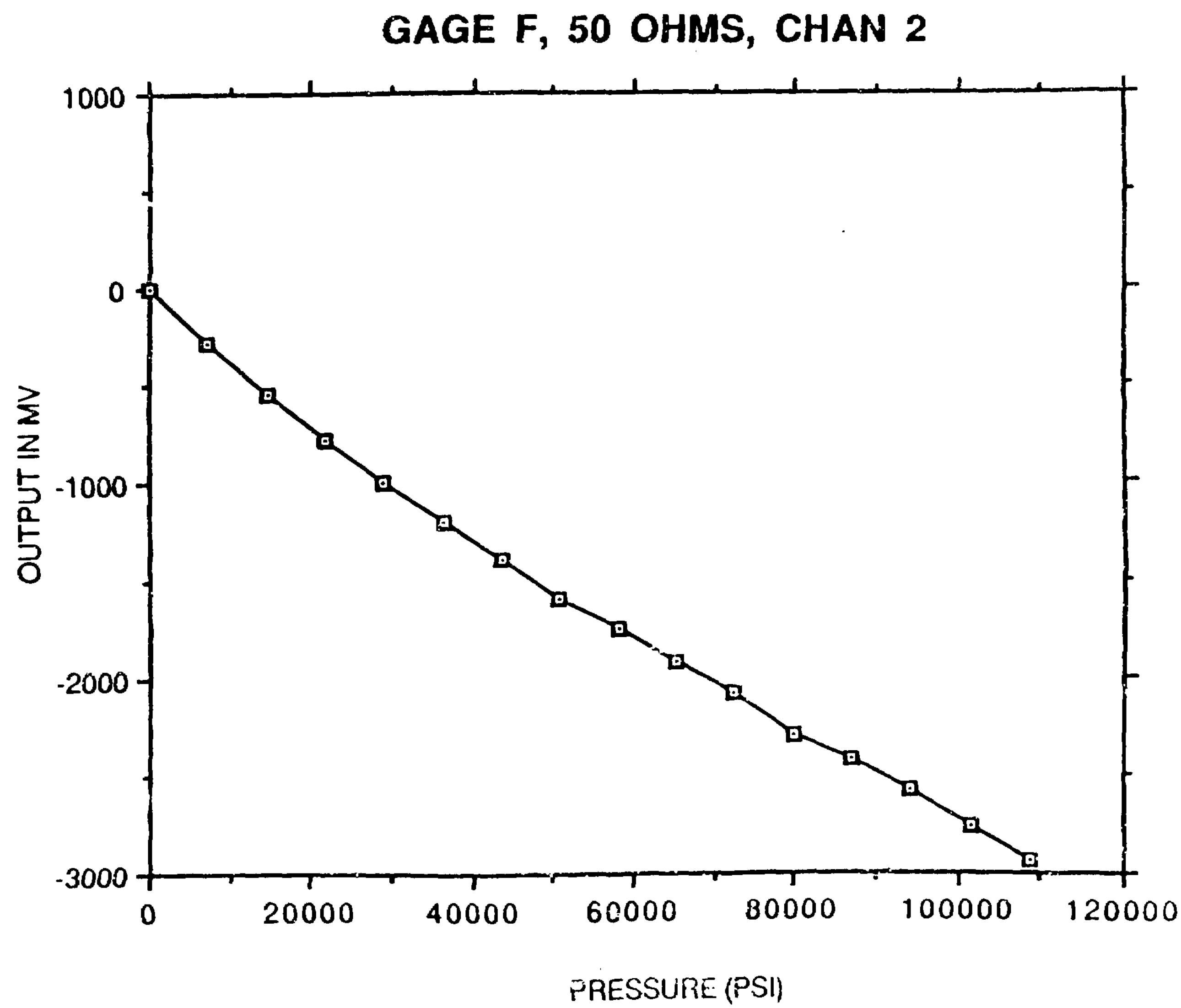


Figure D-6. Gage Calibration Curve.

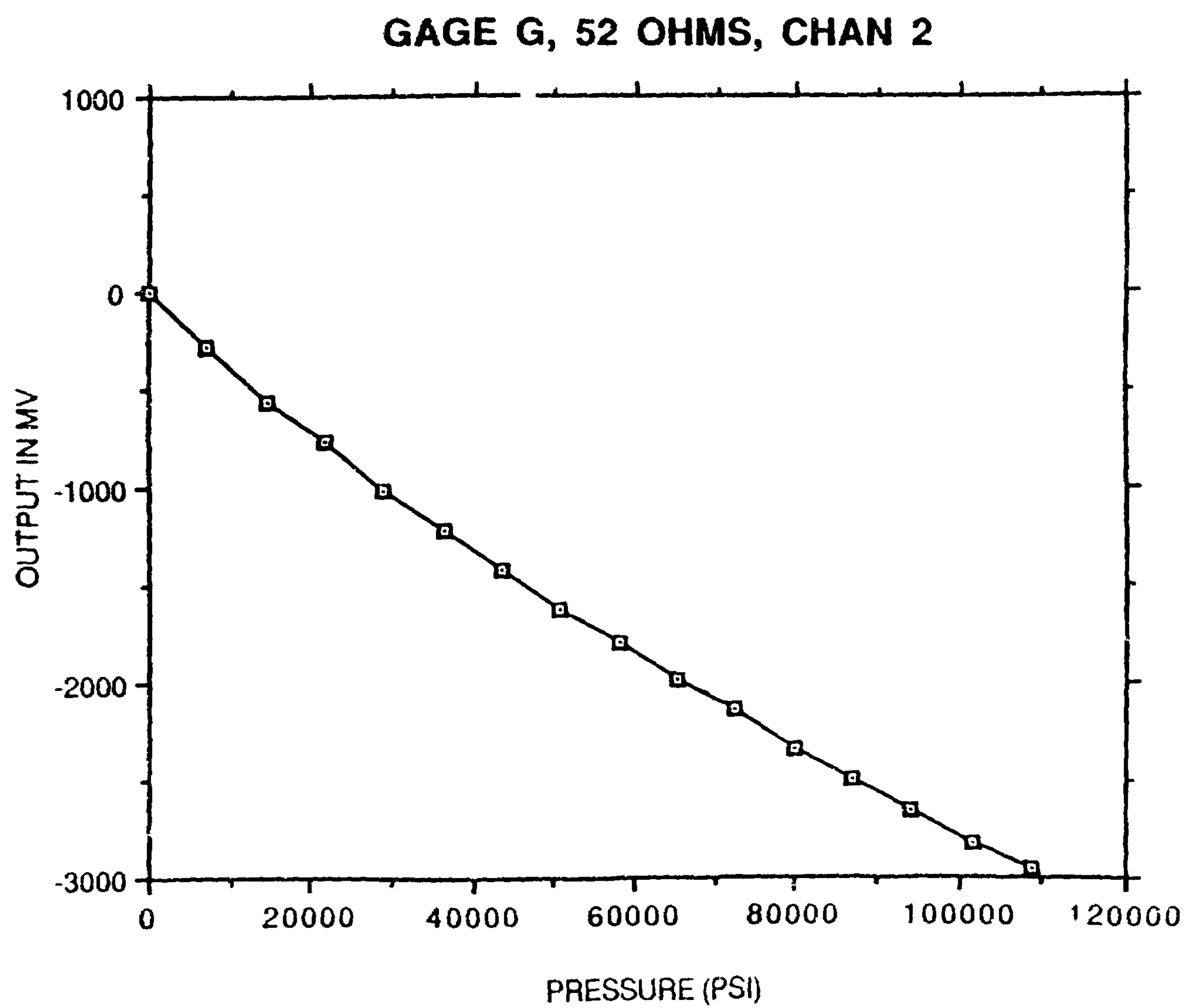


Figure D-7. Gage Calibration Curve.

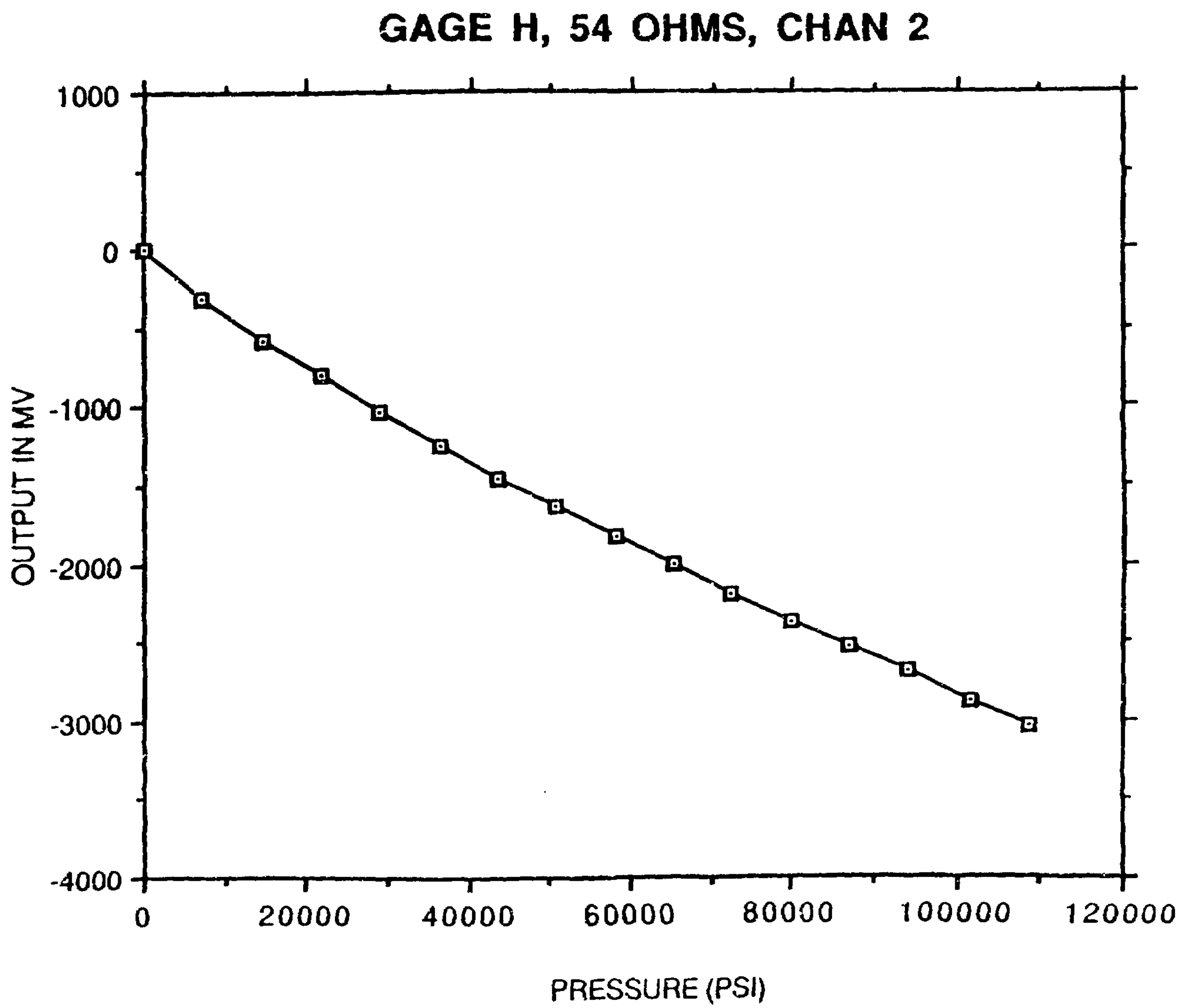


Figure D-8. Gage Calibration Curve.

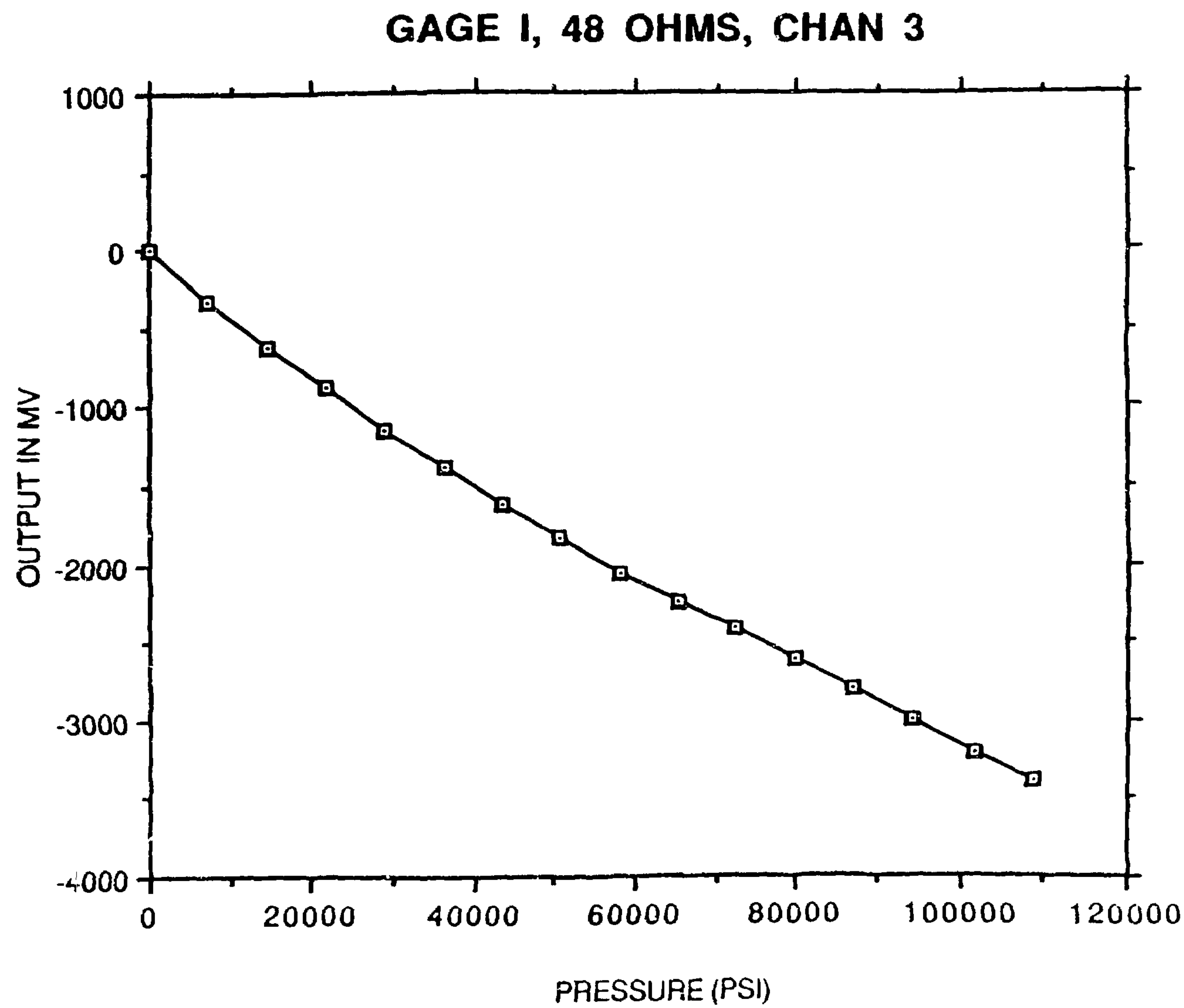


Figure D-9. Gage Calibration Curve.

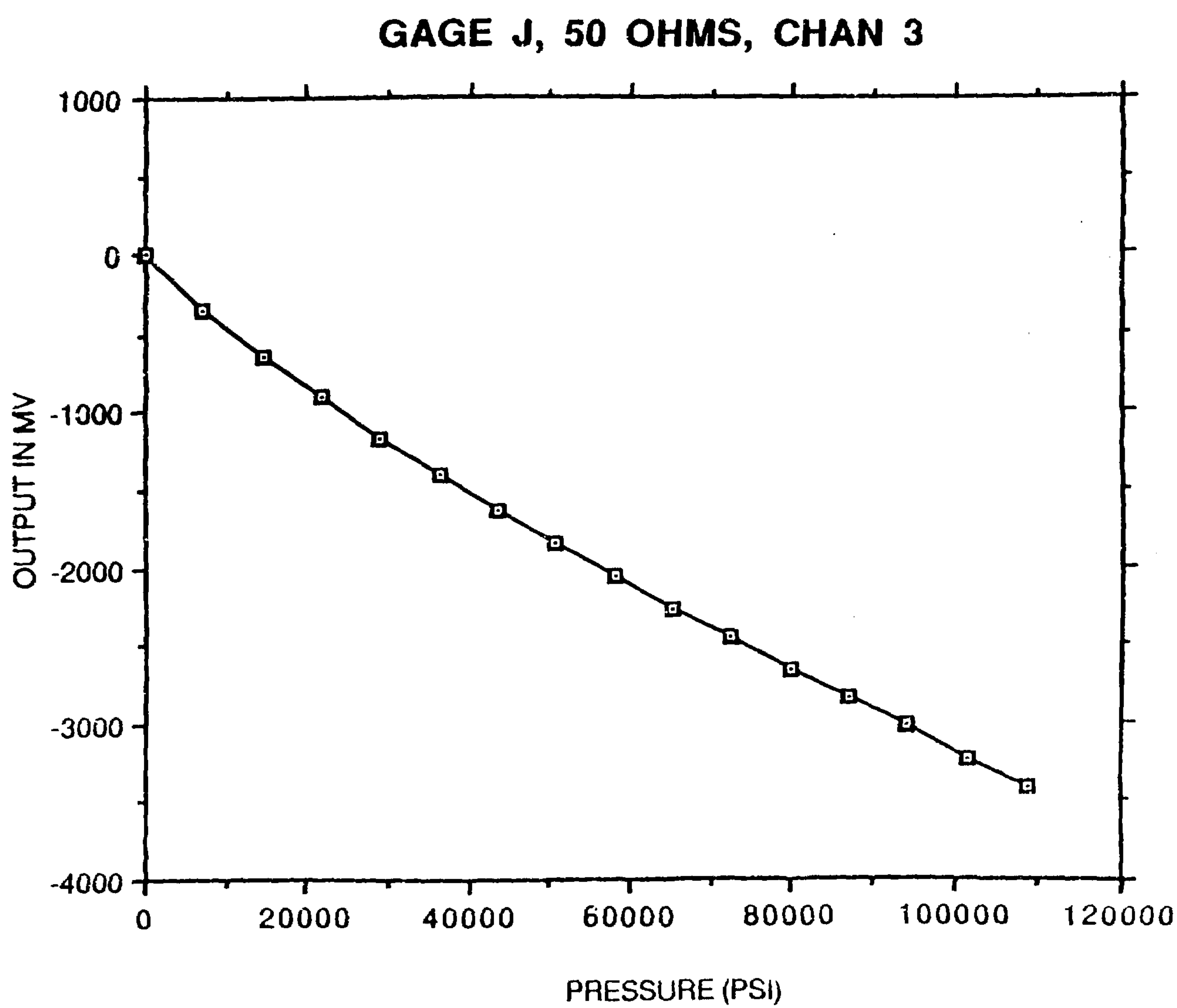


Figure D-10. Gage Calibration Curve.

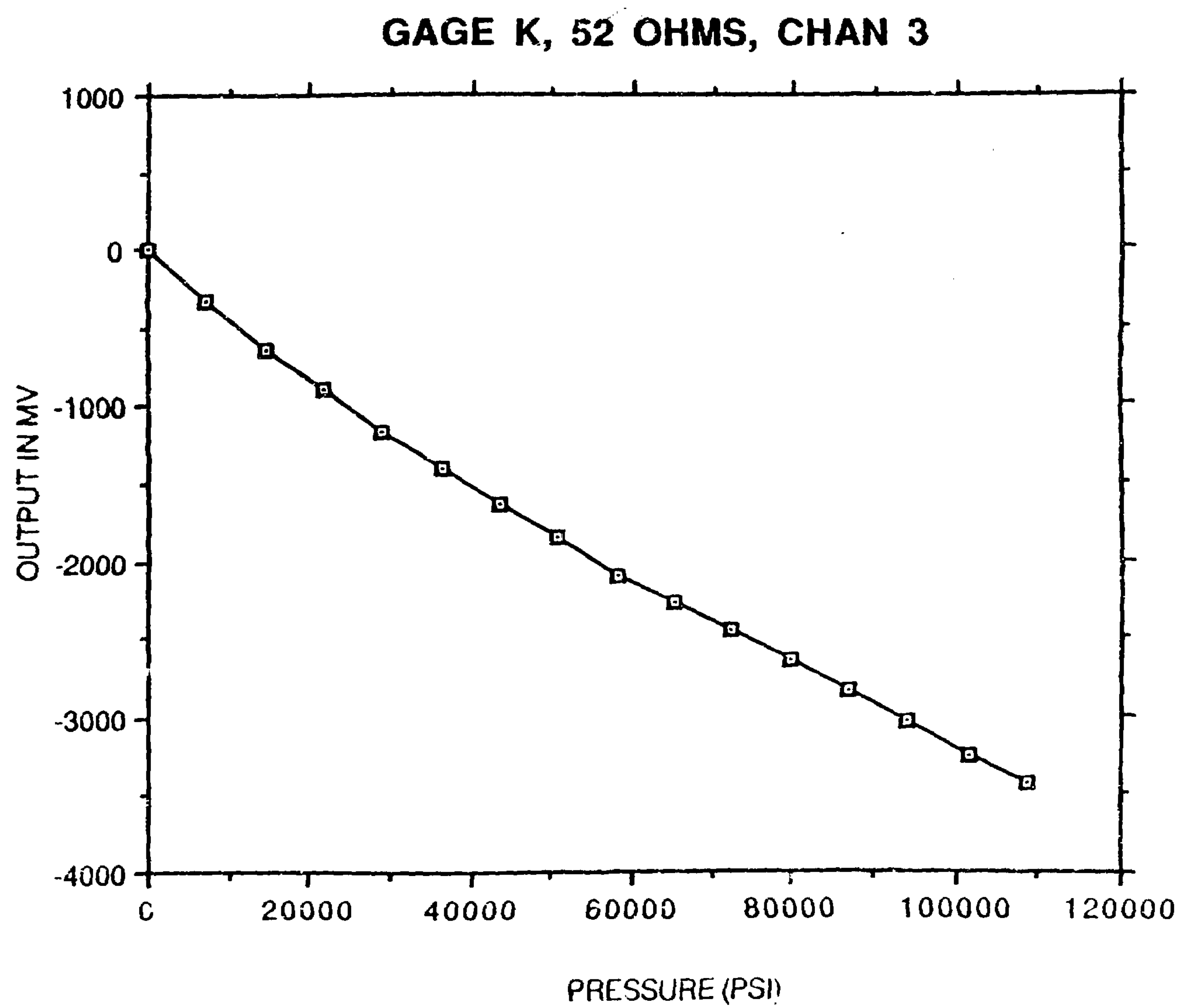


Figure D-11. Gage Calibration Curve.

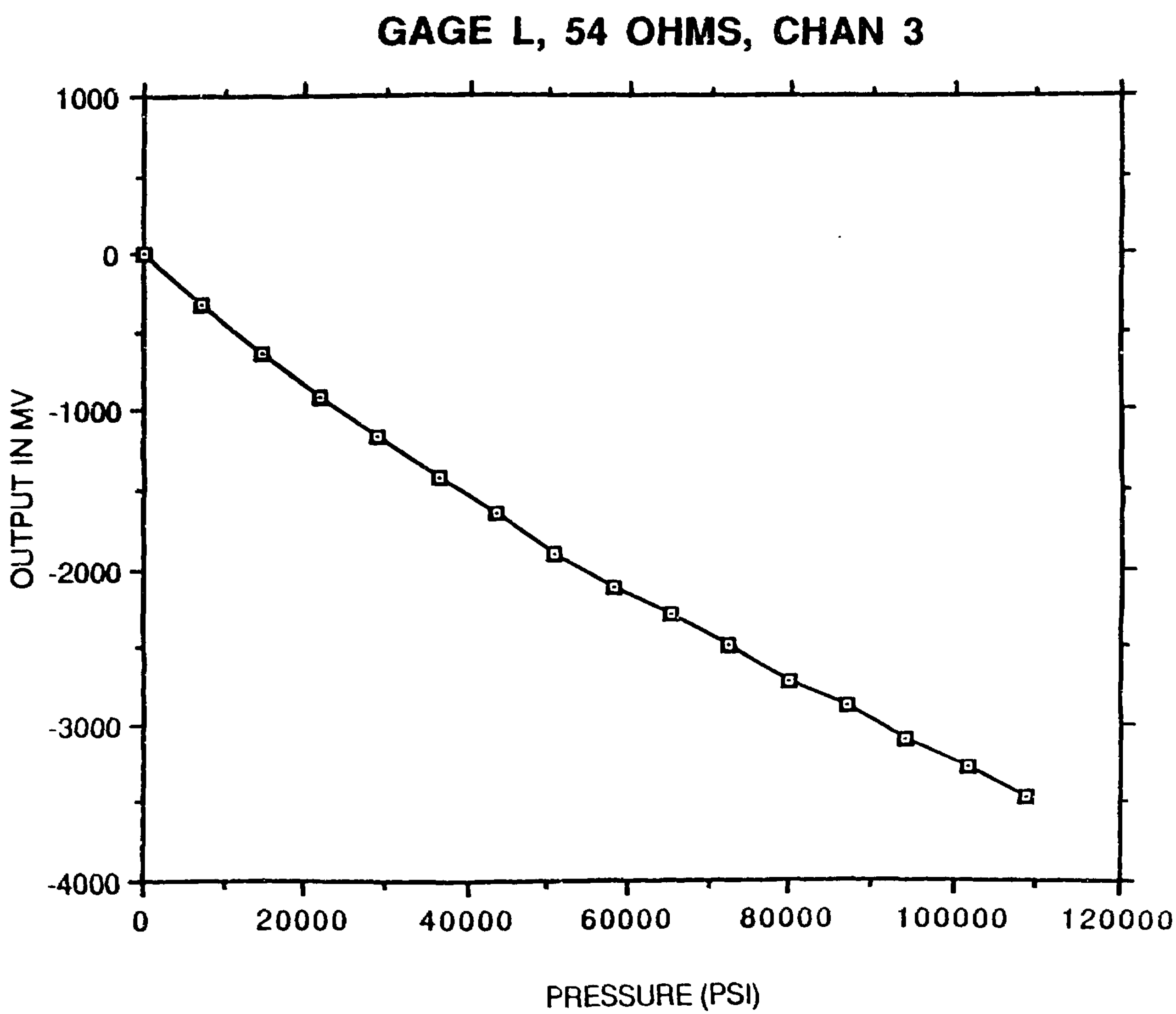


Figure D-12. Gage Calibration Curve.

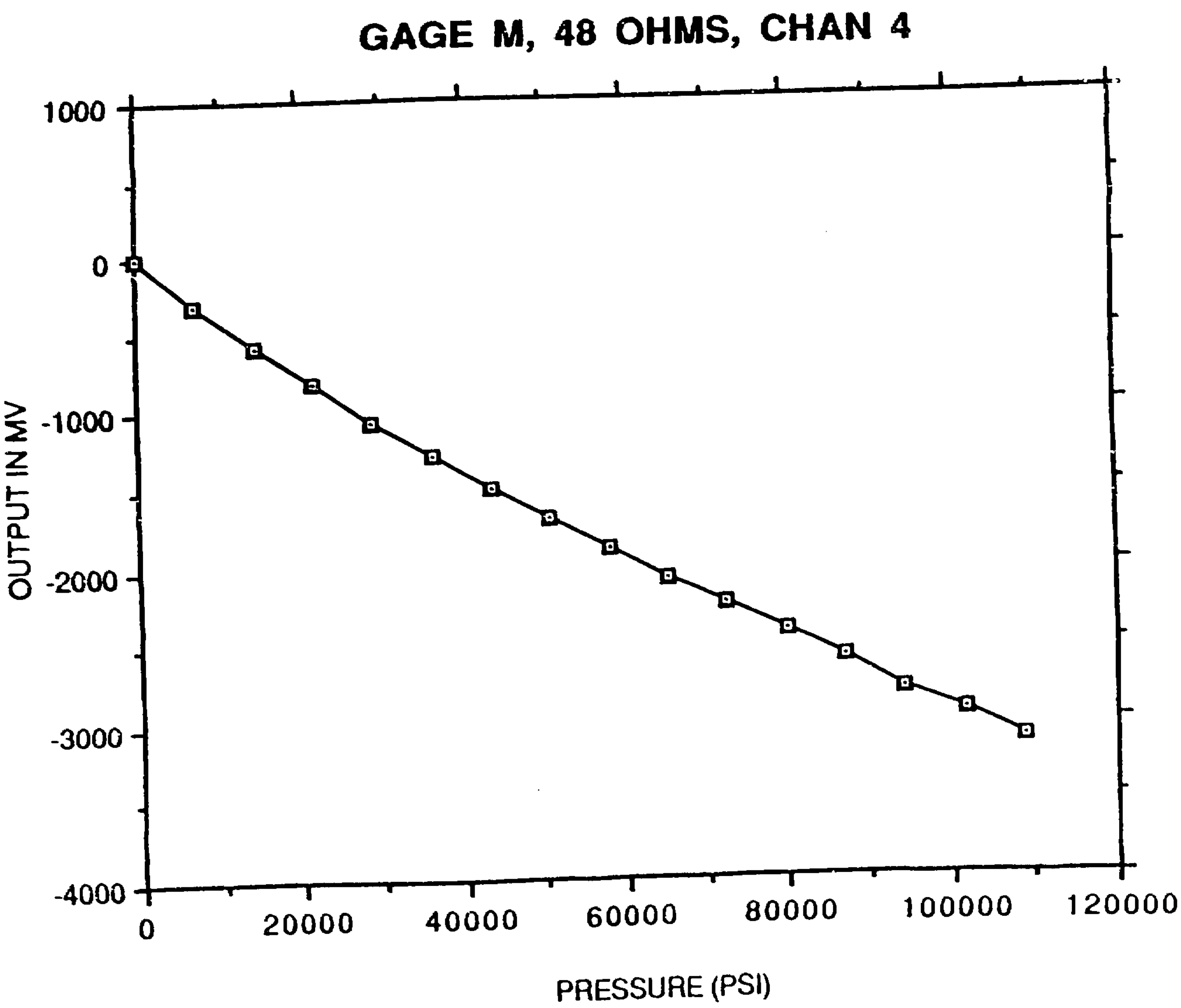


Figure D-13. Gage Calibration Curve.

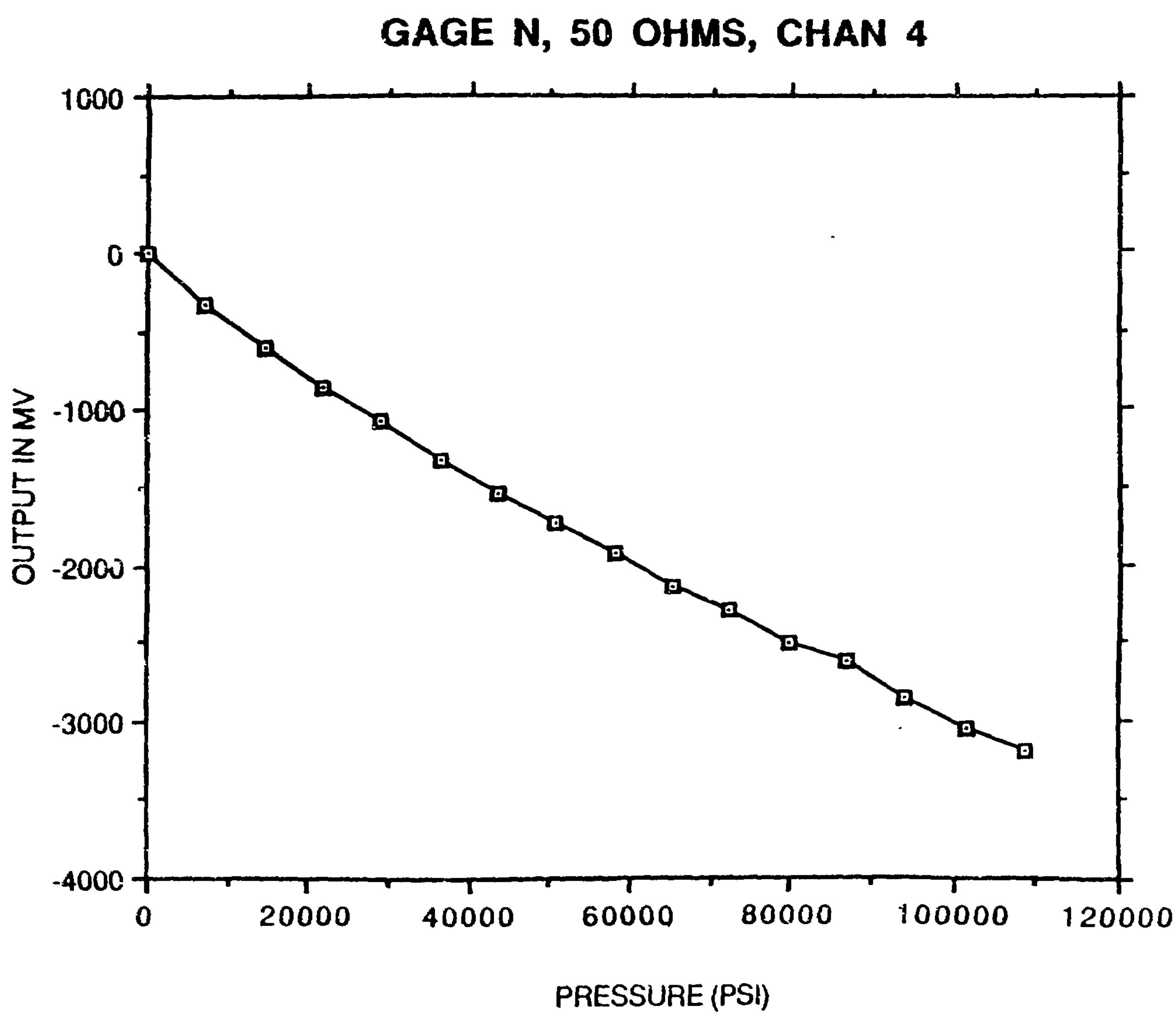


Figure D-14. Gage Calibration Curve.

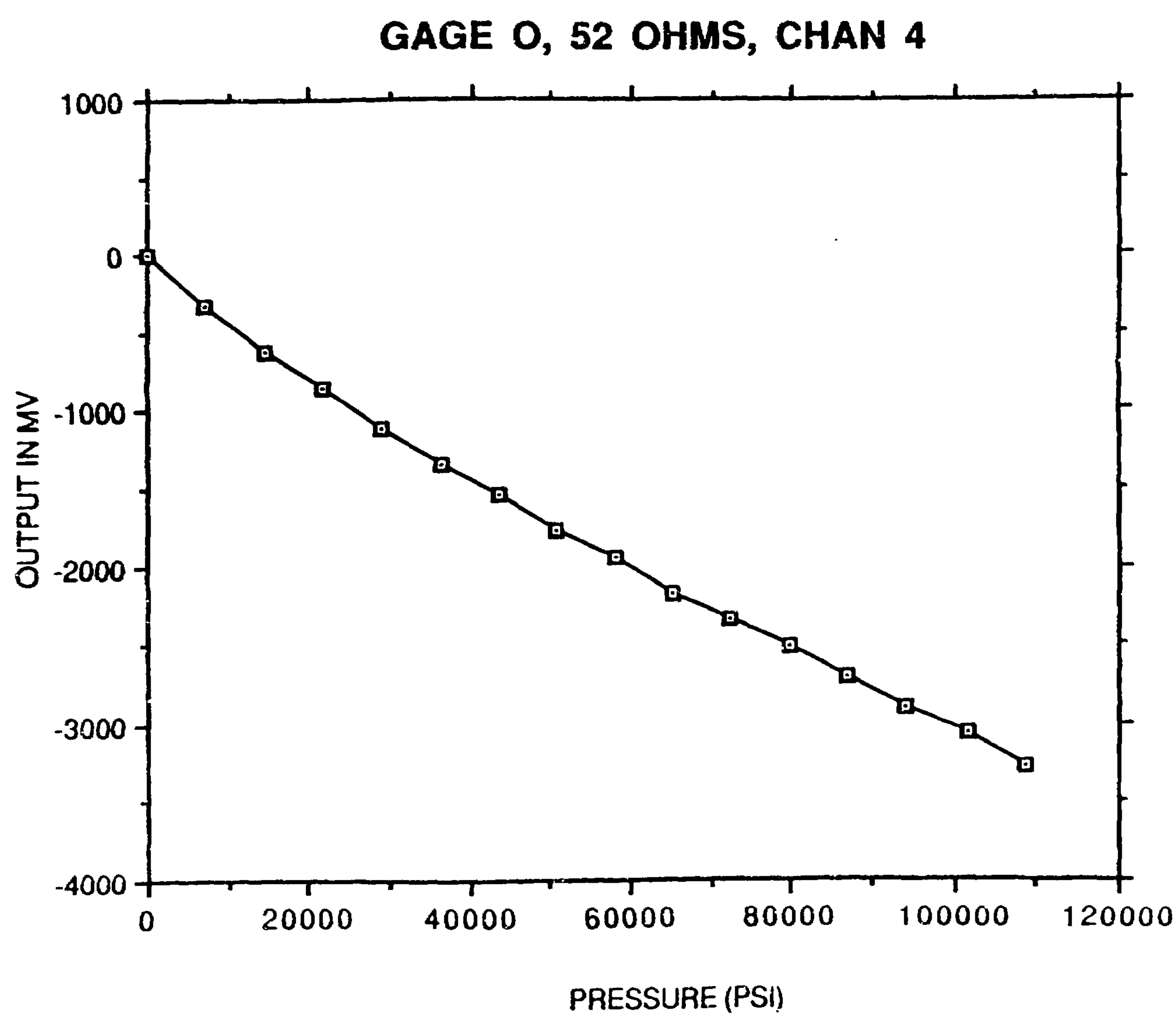


Figure D-15. Gage Calibration Curve.

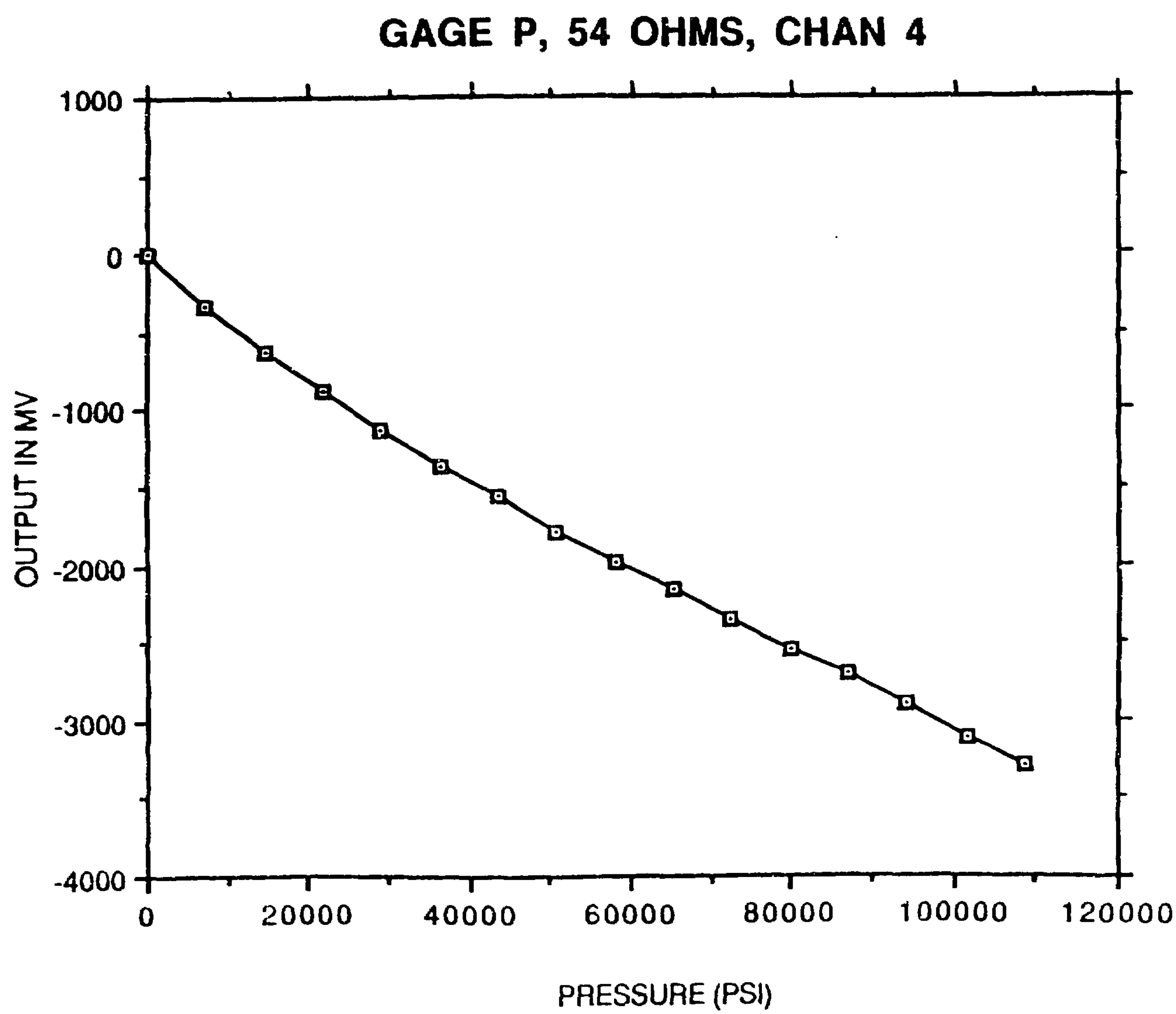


Figure D-16. Gage Calibration Curve.

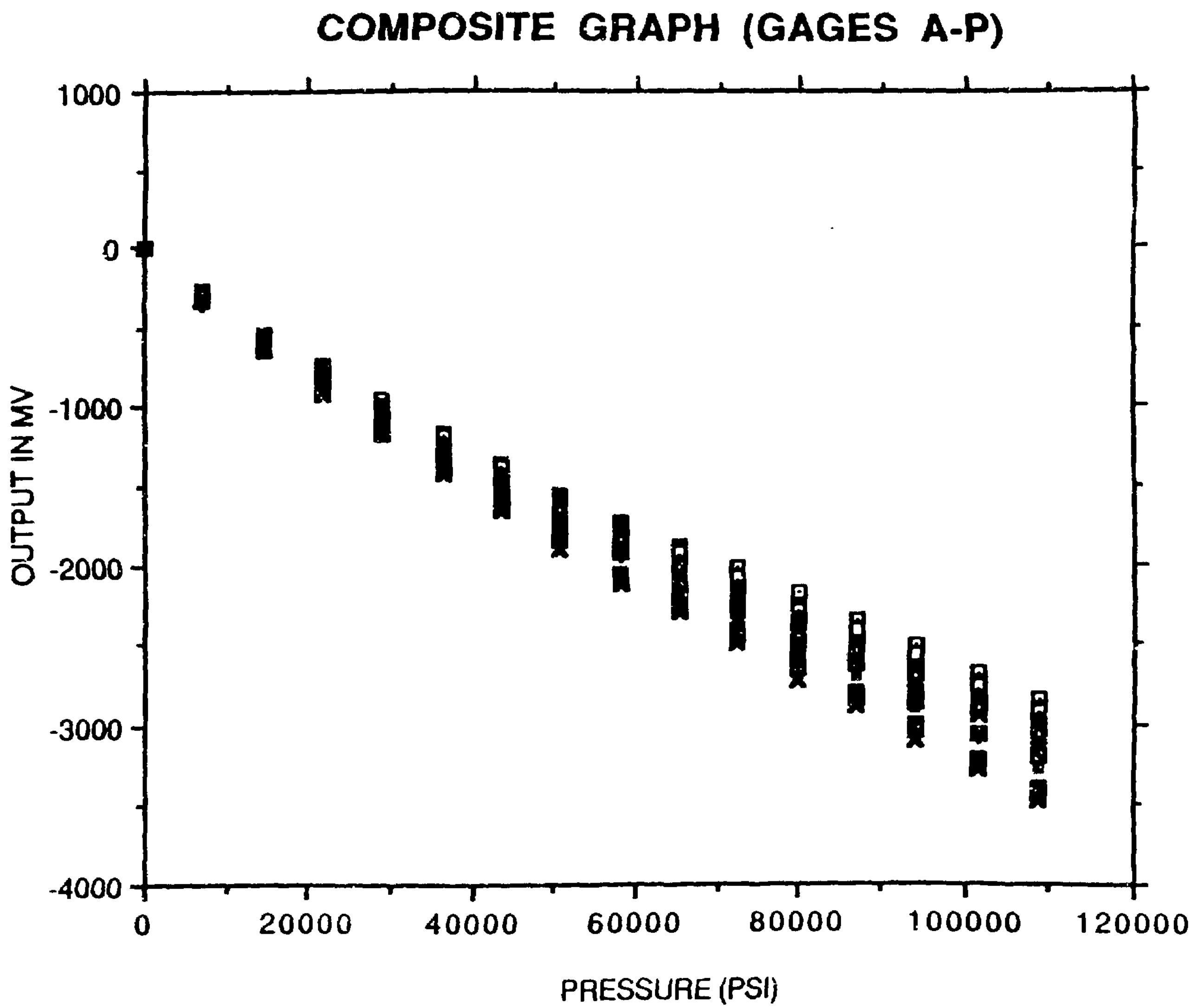


Figure D-17. Composite Calibration Curve.

APPENDIX E

Fragment Data from the 2.7 Pound Cased Charge Test

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST.

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
1	1	3.5	16	0.22	0.228	0.165	0.1	1.381818	-44.5	-8	111.5	120.3183
2	1	15	10.385	0.01	0.118	0.09	0.018	1.311111	-33	-13.615	111.5	117.0752
3	1	13.5	19.25	0.03	0.08	0.127	0.023	0.629921	-34.5	-4.75	111.5	116.8120
4	1	13.825	43.5	0.12	0.266	0.141	0.051	1.886524	-34.175	19.5	111.5	118.2388
5	1	17.25	29	0.02	0.157	0.143	0.019	1.097902	-30.75	5	111.5	115.7705
6	1	17.385	37.5	0.03	0.216	0.119	0.032	1.815126	-30.615	13.5	111.5	116.4121
7	1	30.625	16.5	0.04	0.2	0.085	0.046	2.352941	-17.375	-7.5	111.5	113.0946
8	1	19	24.25	0.02	0.217	0.085	0.021	2.552941	-29	0.25	111.5	115.2098
9	1	45	15.5	0.1	0.185	0.15	0.069	1.233333	-3	-8.5	111.5	111.8637
10	1	20.875	16	0.01	0.139	0.065	0.021	2.138461	-27.125	-8	111.5	115.0304
11	1	44.5	4.25	1.18	0.491	0.271	0.111	1.811808	-3.5	-19.75	111.5	113.2897
12	1	18.5	26.125	0.02	0.119	0.064	0.023	1.859375	-29.5	2.125	111.5	115.3560
13	1	43	6	0.02	0.142	0.1	0.021	1.42	-5	-18	111.5	113.0541
14	1	29.5	10	0.01	0.115	0.058	0.031	1.982758	-18.5	-14	111.5	113.8881
15	1	18.5	31.75	0.06	0.238	0.138	0.063	1.724637	-29.5	7.75	111.5	115.5965
16	1	45.75	6.5	0.02	0.128	0.093	0.039	1.376344	-2.25	-17.5	111.5	112.8873
17	1	15.5	39.75	0.1	0.206	0.175	0.044	1.177142	-32.5	15.75	111.5	117.2030
18	1	18	44.25	0.05	0.276	0.093	0.033	2.967741	-30	20.25	111.5	117.2276
19	1	69.5	8	0.06	0.211	0.189	0.026	1.116402	21.5	-16	111.5	114.6756
20	1	20.5	35	0.01	0.112	0.09	0.015	1.244444	-27.5	11	111.5	115.3668
21	1	22	39.5	0.01	0.15	0.052	0.027	2.884615	-26	15.5	111.5	115.5357
22	1	60.5	9	0.03	0.147	0.075	0.023	1.96	12.5	-15	111.5	113.1967
23	1	21.75	24	0.02	0.166	0.1	0.025	1.66	-26.25	0	111.5	114.5482
24	1	58.5	17.25	0.04	0.215	0.141	0.035	1.524822	10.5	-6.75	111.5	112.1965
25	1	22	26.5	0.05	0.218	0.184	0.026	1.184782	-26	2.5	111.5	114.5185
26	1	70	12.5	0.29	0.375	0.271	0.038	1.383763	22	-11.5	111.5	114.2300
27	1	20.75	23.25	0.01	0.121	0.075	0.013	1.613333	-27.25	-0.75	111.5	114.7840
28	1	70.5	14.5	0.11	0.301	0.126	0.043	2.388888	22.5	-9.5	111.5	114.1435
29	1	22.25	29.25	0.01	0.103	0.089	0.028	1.157303	-25.75	5.25	111.5	114.5551
30	1	74.5	10.5	0.16	0.425	0.134	0.083	3.171641	26.5	-13.5	111.5	115.3982
31	1	22.5	45.25	0.02	0.13	0.097	0.026	1.340206	-25.5	21.25	111.5	116.3359
32	1	79	6.5	0.08	0.253	0.135	0.042	1.874074	31	-17.5	111.5	117.0448
33	1	24	34.75	0.02	0.161	0.111	0.043	1.450450	-24	10.75	111.5	114.5592
34	1	46	25.25	0.01	0.109	0.103	0.03	1.058252	-2	1.25	111.5	111.5249
35	1	23	46.5	0.02	0.147	0.127	0.027	1.157480	-25	22.5	111.5	116.4624
36	1	73	38	0.01	0.114	0.073	0.029	1.561643	30	14	111.5	116.3110
37	1	23	19.5	0.03	0.223	0.105	0.024	2.123809	-25	-4.5	111.5	114.3568
38	1	78	42	0.22	0.349	0.234	0.072	1.491452	30	18	111.5	116.8599
39	1	79.5	41	0.07	0.351	0.106	0.056	3.311320	31.5	17	111.5	117.1046
40	1	21.5	33.75	0.01	0.119	0.099	0.035	1.202020	-26.5	9.75	111.5	115.0198
41	1	76.5	39.5	0.03	0.223	0.071	0.035	3.140845	28.5	15.5	111.5	116.1238
42	1	17.5	35	0.02	0.175	0.116	0.02	1.508620	-30.5	11	111.5	116.1184
43	1	77.5	46	0.11	0.255	0.176	0.041	1.448863	29.5	22	111.5	117.4159
44	1	95	4.5	0.04	0.189	0.121	0.033	1.561983	47	-19.5	111.5	122.5622
45	1	78.5	13.25	0.02	0.129	0.127	0.031	1.015748	30.5	-10.75	111.5	116.0950
46	1	24	19.75	0.01	0.153	0.069	0.02	2.217391	-24	-4.25	111.5	114.1328
47	1	59	20.5	0.01	0.091	0.057	0.018	1.596491	11	-3.5	111.5	112.0959
48	1	71.5	46	0.03	0.132	0.109	0.028	1.211009	23.5	22	111.5	116.0538
49	1	93	47.5	0.03	0.136	0.105	0.029	1.295238	45	23.5	111.5	122.5132
50	1	27.75	8.75	0.03	0.164	0.097	0.023	1.690721	-20.25	-15.25	111.5	114.3454
51	1	82	39.5	0.03	0.212	0.122	0.029	1.737704	34	15.5	111.5	117.5946
52	1	26	32.25	0.1	0.302	0.125	0.035	2.416	-22	8.25	111.5	113.9487

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG	THN X	THN Y	PENET	RATION	COORDINATE	DEPTH	Xo	Yo	PRESENTED	AREA
NUM			X'(in)	Y'(in)	Z'(in)	R'(in)			MAX.	MIN.
1	-0.39910	-0.07174	-0.13955	-0.03587	0.5	0.539544	-44.3004	-7.96412	0.017112	0.007505
2	-0.29596	-0.12210	-0.14798	-0.06105	0.5	0.525001	-32.8520	-13.5539	0.004321	0.000659
3	-0.30941	-0.04260	-0.15470	-0.02130	0.5	0.523820	-34.3452	-4.72869	0.010145	0.002916
4	-0.30650	0.174887	0.15325	0.087443	0.5	0.530219	-34.0217	19.41255	0.018302	0.003509
5	-0.27578	0.044843	0.13789	0.022421	0.5	0.519150	-30.6121	4.977578	0.008187	0.000990
6	-0.27457	0.121076	-0.13728	0.060533	0.5	0.522027	-30.4777	13.43946	0.007292	0.001080
7	-0.15582	-0.06726	-0.07791	-0.03363	0.5	0.507150	-17.2970	-7.46636	0.006763	0.001555
8	-0.26008	0.002242	-0.13004	0.001121	0.5	0.516636	-28.8699	0.248878	0.007408	0.000716
9	-0.02690	-0.07623	-0.01345	-0.03811	0.5	0.501631	-2.98654	-8.46188	0.011273	0.004204
10	-0.24327	-0.07174	-0.12163	-0.03587	0.5	0.515831	-27.0033	-7.96412	0.003704	0.000559
11	-0.03139	-0.17713	-0.01569	-0.08856	0.5	0.508025	-3.48430	-19.6614	0.082690	0.018693
12	-0.26457	0.019058	-0.13228	0.009529	0.5	0.517291	-29.3677	2.115470	0.006763	0.001307
13	-0.04484	-0.16143	-0.02242	-0.08071	0.5	0.506969	-4.97757	-17.9192	0.007408	0.001095
14	-0.16591	-0.12556	-0.08295	-0.06278	0.5	0.510708	-18.4170	-13.9372	0.002509	0.000676
15	-0.26457	0.069506	-0.13228	0.034753	0.5	0.518370	-29.3677	7.715246	0.007408	0.001960
16	-0.02017	-0.15695	-0.01008	-0.07847	0.5	0.506221	-2.23991	-17.4215	0.003988	0.001215
17	-0.29147	0.141255	-0.14573	0.070627	0.5	0.525574	-32.3542	15.67937	0.017678	0.003775
18	-0.26905	0.181614	-0.13452	0.090807	0.5	0.525684	-29.8654	20.15919	0.011785	0.001409
19	0.192825	-0.14349	0.096412	-0.07174	0.5	0.514240	21.40358	-15.9282	0.017950	0.002211
20	-0.24663	0.098654	-0.12331	0.049327	0.5	0.517339	-27.3766	10.95067	0.005185	0.000694
21	-0.23318	0.139013	-0.11659	0.069506	0.5	0.518097	-25.8834	15.43049	0.002880	0.000518
22	0.112107	-0.13452	0.056053	-0.06726	0.5	0.507608	12.44394	-14.9327	0.010145	0.001587
23	-0.23542	0	-0.11771	0	0.5	0.513669	-26.1322	0	0.006222	0.000937
24	0.094170	-0.06053	0.047085	-0.03026	0.5	0.503123	10.45291	-6.71973	0.008889	0.001447
25	-0.23318	0.022421	-0.11659	0.011210	0.5	0.513536	-25.8834	2.488789	0.014958	0.001784
26	0.197309	-0.10313	0.098654	-0.05156	0.5	0.512242	21.90134	-11.4484	0.059362	0.006015
27	-0.24439	-0.00672	-0.12219	-0.00336	0.5	0.514726	-27.1278	-0.74663	0.005983	0.000642
28	0.201793	-0.08520	0.100896	-0.04260	0.5	0.511854	22.39910	-9.45739	0.019898	0.002842
29	-0.23094	0.047085	-0.11547	0.023542	0.5	0.513700	-25.6345	5.226457	0.002778	0.000755
30	0.237668	-0.12107	0.118834	-0.06053	0.5	0.517460	26.38116	-13.4394	0.014994	0.002928
31	-0.22869	0.190582	-0.11434	0.095291	0.5	0.521686	-25.3856	21.15470	0.005983	0.001196
32	0.278026	-0.15695	0.139013	-0.07847	0.5	0.524864	30.86098	-17.4215	0.014816	0.002459
33	-0.21524	0.096412	-0.10762	0.048206	0.5	0.513718	-23.8923	10.70179	0.003617	0.000966
34	-0.01793	0.011210	-0.00896	0.005605	0.5	0.500111	-1.99103	1.244394	0.002592	0.000713
35	-0.22421	0.201793	-0.11210	0.100896	0.5	0.522253	-24.8878	22.39910	0.005761	0.001058
36	0.269058	0.125560	0.134529	0.062780	0.5	0.521574	29.86547	13.93721	0.002682	0.000682
37	-0.22421	-0.04035	-0.11210	-0.02017	0.5	0.512811	-24.8878	-4.47982	0.009723	0.001046
38	0.269058	0.161434	0.134529	0.080717	0.5	0.524035	29.86547	17.91928	0.023767	0.004903
39	0.282511	0.152466	0.141255	0.076233	0.5	0.525132	31.35874	16.92376	0.009723	0.001551
40	-0.23766	0.087443	-0.11883	0.043721	0.5	0.515784	-26.3811	9.706278	0.002222	0.000653
41	0.255605	0.139013	0.127802	0.069506	0.5	0.520734	28.37219	15.43049	0.006667	0.001046
42	-0.27354	0.098654	-0.13677	0.049327	0.5	0.520710	-30.3632	10.95067	0.007778	0.000888
43	0.264573	0.197309	0.132286	0.098654	0.5	0.526528	29.36771	21.90134	0.020869	0.003355
44	0.421524	-0.17488	0.210762	-0.08744	0.5	0.549606	46.78923	-19.4125	0.009428	0.001646
45	0.273542	-0.09641	0.136771	-0.04820	0.5	0.520605	30.36322	-10.7017	0.005018	0.001205
46	-0.21524	-0.03811	-0.10762	-0.01905	0.5	0 511806	-23.8923	-4.23094	0.003839	0.000508
47	0.098654	-0.03139	0.049327	-0.01569	0.5	0.502672	10.95067	-3.48430	0.004321	0.000854
48	0.210762	0.197309	0.105381	0.098654	0.5	0.520420	23.39461	21.90134	0.008334	0.001767
49	0.403587	0.210762	0.201793	0.105381	0.5	0.549386	44.79820	23.39461	0.008046	0.001715
50	-0.18161	-0.13677	-0.09080	-0.06838	0.5	0.512759	-20.1591	-15.1816	0.010145	0.001422
51	0.304932	0.139013	0.152466	0.069506	0.5	0.527330	33.84753	15.43049	0.008046	0.001100
52	-0.19730	0.073991	-0.09865	0.036995	0.5	0.510980	-21.9013	8.213004	0.017285	0.002575

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	(IN)³ AVG.	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Xi	Locations Yi	(1-4)	VEL. (fps)	MV lb-sec -10+-7.5	MV lb-sec -7.5+-5
1	0.012309	17.87297	532.8590	287.1846	410.0218	0.006175	-99	-99	0	0	0.00E+00	0.00E+00
2	0.002490	4.015609	1889.113	461.1060	1175.109	0.000804	1	-99	0	0	0.00E+00	0.00E+00
3	0.006531	4.593211	1569.218	616.1150	1092.666	0.002244	1	1	1	1092.666	0.00E+00	0.00E+00
4	0.010905	11.00343	871.4772	252.5064	561.9918	0.004617	1	99	0	0	0.00E+00	0.00E+00
5	0.004589	4.357891	1798.857	369.0942	1083.975	0.001484	1	1	1	1083.975	0.00E+00	0.00E+00
6	0.004186	7.166183	1221.798	291.7573	756.7779	0.001554	1	99	0	0	0.00E+00	0.00E+00
7	0.004159	9.615869	910.7025	302.4631	606.5828	0.001661	2	-99	0	0	0.00E+00	0.00E+00
8	0.004062	4.923091	1662.709	288.4934	975.6012	0.001335	1	1	1	975.6012	0.00E+00	0.00E+00
9	0.007738	12.92179	666.4134	318.0546	492.2340	0.003370	2	-99	0	0	0.00E+00	0.00E+00
10	0.002131	4.690833	1660.767	402.4501	1031.608	0.000706	1	-99	0	0	0.00E+00	0.00E+00
11	0.050691	23.27790	470.9926	154.4170	312.7048	0.025263	2	-99	0	0	2.53E-02	0.00E+00
12	0.004035	4.955897	1554.525	453.1411	1003.833	0.001374	1	1	1	1003.833	0.00E+00	0.00E+00
13	0.004251	4.703876	1639.321	390.9419	1015.131	0.001390	2	-99	0	0	0.00E+00	1.39E-03
14	0.001592	6.278906	1230.838	460.4673	845.6528	0.000579	1	-99	0	0	0.00E+00	0.00E+00
15	0.004684	12.80816	731.2514	269.8605	500.5560	0.002056	1	99	0	0	0.00E+00	0.00E+00
16	0.002602	7.685886	1029.316	422.1240	725.7204	0.000993	2	-99	0	0	0.00E+00	9.94E-04
17	0.010727	9.322142	967.1153	303.8556	635.4854	0.004350	1	99	0	0	0.00E+00	0.00E+00
18	0.006597	7.578799	1200.191	244.0361	722.1137	0.002471	1	99	0	0	0.00E+00	0.00E+00
19	0.010081	5.951731	1411.681	293.5992	852.6405	0.003502	4	-99	0	0	0.00E+00	3.50E-03
20	0.002940	3.401272	2142.178	474.2535	1308.216	0.000895	1	99	0	0	0.00E+00	0.00E+00
21	0.001699	5.883254	1379.996	381.3574	880.6767	0.000602	1	99	0	0	0.00E+00	0.00E+00
22	0.005866	5.113663	1532.650	381.2860	956.9680	0.001965	3	-99	0	0	0.00E+00	1.97E-03
23	0.003579	5.586638	1452.613	351.1752	901.8941	0.001234	1	1	1	901.8941	0.00E+00	0.00E+00
24	0.005168	7.739312	1111.212	284.7863	697.9993	0.001911	3	-99	0	0	0.00E+00	0.00E+00
25	0.008371	5.972771	1410.231	286.2055	848.2184	0.002903	1	1	1	848.2184	0.00E+00	0.00E+00
26	0.032688	8.871573	1058.914	190.1845	624.5496	0.012400	4	-99	0	0	0.00E+00	0.00E+00
27	0.003313	3.018281	2375.839	445.8467	1410.843	0.000965	1	1	1	1410.843	0.00E+00	0.00E+00
28	0.011370	9.67414	964.6076	224.1440	594.3758	0.004476	4	-99	0	0	0.00E+00	0.00E+00
29	0.001766	5.660565	1334.307	502.3384	918.3228	0.000628	1	1	1	918.3228	0.00E+00	0.00E+00
30	0.008961	17.85414	593.8876	174.4701	384.1788	0.004208	4	-99	0	0	0.00E+00	0.00E+00
31	0.003590	5.570933	1426.983	426.7677	926.8757	0.001269	1	99	0	0	0.00E+00	0.00E+00
32	0.008637	9.261549	1000.439	260.1880	630.3137	0.003452	4	-99	0	0	0.00E+00	3.45E-03
33	0.002292	8.725694	967.2409	359.3491	663.2950	0.000908	1	99	0	0	0.00E+00	0.00E+00
34	0.001653	6.048794	1241.799	471.8702	856.8349	0.000586	2	1	2	856.8349	0.00E+00	0.00E+00
35	0.003410	5.864995	1388.289	389.5066	888.8981	0.001217	1	99	0	0	0.00E+00	0.00E+00
36	0.001682	5.944326	1314.560	470.8693	892.7149	0.000611	4	99	0	0	0.00E+00	0.00E+00
37	0.005384	5.571280	1495.897	281.0810	888.4892	0.001824	1	1	1	888.4892	0.00E+00	0.00E+00
38	0.014335	15.34658	666.9809	204.1708	435.5758	0.006560	4	99	0	0	0.00E+00	0.00E+00
39	0.005637	12.41756	806.5904	203.6168	505.1036	0.002420	4	99	0	0	0.00E+00	0.00E+00
40	0.001438	6.953927	1132.118	452.1503	792.1345	0.000542	1	99	0	0	0.00E+00	0.00E+00
41	0.003856	7.778378	1140.259	284.3321	712.2956	0.001463	4	99	0	0	0.00E+00	0.00E+00
42	0.004333	4.614974	1734.870	341.0051	1037.937	0.001421	1	99	0	0	0.00E+00	0.00E+00
43	0.012112	9.081721	1021.106	259.2708	640.1884	0.004821	4	99	0	0	0.00E+00	0.00E+00
44	0.005537	7.223682	1240.924	335.1850	788.0550	0.002158	99	-99	0	0	0.00E+00	2.16E-03
45	0.003112	6.426393	1248.683	428.5796	838.6317	0.001148	4	-99	0	0	0.00E+00	0.00E+00
46	0.002198	4.547902	1712.572	372.3085	1042.440	0.000713	1	1	1	1042.440	0.00E+00	0.00E+00
47	0.002588	3.863876	1828.527	542.3440	1185.435	0.000811	3	1	3	1185.435	0.00E+00	0.00E+00
48	0.005050	5.939472	1347.378	421.1412	884.2599	0.001816	4	99	0	0	0.00E+00	0.00E+00
49	0.004881	6.145947	1366.791	428.8907	897.8411	0.001844	99	99	0	0	0.00E+00	0.00E+00
50	0.005784	5.186399	1544.300	353.9115	949.1057	0.001949	1	-99	0	0	0.00E+00	1.95E-03
51	0.004573	6.559227	1325.426	298.1276	811.7770	0.001667	4	99	0	0	0.00E+00	0.00E+00
52	0.009990	10.06991	931.0783	223.3008	577.1895	0.003951	1	99	0	0	0.00E+00	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -5+-2.5	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+10
1	0.00E+00	6.18E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	8.05E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	2.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-03	0.00E+00
5	0.00E+00	0.00E+00	1.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-03	0.00E+00	0.00E+00
7	0.00E+00	1.66E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	1.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	3.37E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	7.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	1.37E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	5.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	0.00E+00	0.00E+00	2.06E-03	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-03	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.47E-03
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.96E-04	0.00E+00	0.00E+00
21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.03E-04	0.00E+00
22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	1.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	1.91E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	0.00E+00	0.00E+00	2.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	1.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	0.00E+00	0.00E+00	9.66E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	0.00E+00	4.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	0.00E+00	0.00E+00	6.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-03
32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E-04	0.00E+00	0.00E+00
34	0.00E+00	0.00E+00	5.87E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-03
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.11E-04	0.00E+00	0.00E+00
37	0.00E+00	0.00E+00	1.82E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.56E-03	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.42E-03	0.00E+00
40	0.00E+00	0.00E+00	0.00E+00	5.42E-04	0.00E+00	0.00E+00	0.00E+00
41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-03	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-03	0.00E+00	0.00E+00
43	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.82E-03
44	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	0.00E+00	0.00E+00	7.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	0.00E+00	0.00E+00	8.12E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.82E-03
49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-03
50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-03	0.00E+00
52	0.00E+00	0.00E+00	0.00E+00	3.95E-03	0.00E+00	0.00E+00	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
53	1	61	45.5	0.07	0.253	0.141	0.04	1.794326	13	21.5	111.5	114.2956
54	1	63	45.25	0.09	0.251	0.111	0.052	2.261261	15	21.25	111.5	114.4937
55	1	67.75	0.32	0.02	0.143	0.06	0.038	2.383333	19.75	-23.68	111.5	115.6851
56	1	45.75	45	0.02	0.182	0.141	0.041	1.290780	-2.25	21	111.5	113.4826
57	1	50.5	43.5	0.11	0.394	0.142	0.09	2.774647	2.5	19.5	111.5	113.2199
58	1	58	40.5	0.03	0.178	0.109	0.026	1.633027	10	16.5	111.5	113.1569
59	1	53.5	39.25	0.03	0.291	0.082	0.018	3.548780	5.5	15.25	111.5	112.6723
60	1	73	29.5	0.01	0.11	0.057	0.014	1.929824	25	5.5	111.5	114.4006
61	1	89.5	28.25	0.02	0.166	0.101	0.045	1.643564	41.5	4.25	111.5	119.0485
62	1	43.5	21.25	0.12	0.37	0.2	0.045	1.85	-4.5	-2.75	111.5	111.6246
63	1	49.5	22.75	0.09	0.324	0.161	0.04	2.012422	1.5	-1.25	111.5	111.5170
64	1	49.5	11.75	0.11	0.345	0.16	0.03	2.15625	1.5	-12.25	111.5	112.1809
65	1	53.25	6.5	0.05	0.376	0.137	0.024	2.744525	5.25	-17.5	111.5	112.9870
66	1	55	14.75	0.02	0.13	0.087	0.029	1.494252	7	-9.25	111.5	112.1017
67	1	38.75	6	0.12	0.235	0.153	0.079	1.487341	-9.25	-18	111.5	113.3217
68	1	38	20	0.03	0.205	0.105	0.02	1.952380	-10	-4	111.5	112.0189
69	1	42.5	29.5	0.02	0.21	0.081	0.025	2.592592	-5.5	5.5	111.5	111.7709
70	1	54	22.25	0.01	0.113	0.072	0.019	1.569444	6	-1.75	111.5	111.6750
71	1	52	24.5	0.01	0.119	0.08	0.018	1.4875	4	0.5	111.5	111.5728
72	1	61.5	10.75	0.01	0.141	0.084	0.016	1.678571	13.5	-13.25	111.5	113.0931
73	1	23.5	10.75	0.02	0.188	0.049	0.019	3.836734	-24.5	-13.25	111.5	114.9263
74	1	24.5	6.5	0.03	0.134	0.096	0.041	1.395833	-23.5	-17.5	111.5	115.2855
75	1	24.75	22.5	0.17	0.352	0.275	0.037	1.28	-23.25	-1.5	111.5	113.9081
76	1	28.5	20.25	0.1	0.426	0.082	0.038	5.195121	-19.5	-3.75	111.5	113.2544
77	1	29.5	26.5	0.03	0.192	0.072	0.019	2.666666	-18.5	2.5	111.5	113.0519
78	1	30.5	16.5	0.06	0.224	0.161	0.035	1.391304	-17.5	-7.5	111.5	113.1138
79	1	27.5	8.75	0.04	0.219	0.182	0.03	1.203296	-20.5	-15.25	111.5	114.3899
80	1	31	46.25	0.14	0.35	0.15	0.038	2.333333	-17	22.25	111.5	114.9622
81	1	35.5	46	0.11	0.36	0.127	0.045	2.834645	-12.5	22	111.5	114.3350
82	1	76.5	22	0.16	0.352	0.12	0.08	2.933333	28.5	-2	111.5	115.1021
83	1	79	20.75	0.03	0.172	0.128	0.033	1.34375	31	-3.25	111.5	115.7748
84	1	72.5	7.5	0.02	0.204	0.089	0.03	2.292134	24.5	-16.5	111.5	115.3462
85	1	75	45.25	0.05	0.173	0.093	0.027	1.860215	27	21.25	111.5	116.6739
86	1	52	43.25	0.07	0.161	0.121	0.051	1.330578	4	19.25	111.5	113.2201
87	1	64	37.5	0.08	0.236	0.074	0.02	3.189189	16	13.5	111.5	113.4482
88	1	67	26.25	0.05	0.17	0.131	0.03	1.297709	19	2.25	111.5	113.1296
89	1	64.5	41	0.07	0.225	0.116	0.033	1.939655	16.5	17	111.5	113.9890
90	1	38.25	38	0.23	0.47	0.2	0.088	2.35	-9.75	14	111.5	112.7976
91	1	37.5	43	0.05	0.148	0.082	0.035	1.804878	-10.5	19	111.5	113.5935
92	1	28.25	38	0.04	0.218	0.137	0.022	1.591240	-19.75	14	111.5	114.0978
93	1	34.75	25.25	0.02	0.127	0.075	0.022	1.693333	-13.25	1.25	111.5	112.2914
94	1	38.5	36	0.13	0.309	0.162	0.06	1.907407	-9.5	12	111.5	112.5455
95	1	34.75	32.75	0.05	0.199	0.093	0.032	2.139784	-13.25	8.75	111.5	112.6249
96	1	32.25	42.5	0.02	0.179	0.092	0.032	1.945652	-15.75	18.5	111.5	114.1164
97	1	42	29	0.02	0.144	0.095	0.025	1.515789	-6	-1	111.5	111.6657
98	1	31	44.25	0.05	0.203	0.098	0.045	2.071428	-17	20.25	111.5	114.5919
99	1	41.5	40	0.11	0.336	0.07	0.032	4.8	-6.5	16	111.5	112.8295
100	1	55.5	46.5	0.02	0.209	0.145	0.02	1.441379	7.5	22.5	111.5	113.9945
101	1	79	41.5	0.01	0.134	0.094	0.013	1.425531	31	17.5	111.5	117.0448
102	1	86	40.5	0.01	0.078	0.1	0.02	0.78	38	16.5	111.5	118.9474
103	1	79.75	28.25	0.01	0.173	0.064	0.032	2.703125	31.75	4.25	111.5	116.0102
104	1	75.75	26.25	0.03	0.178	0.09	0.021	1.977777	27.75	2.25	111.5	114.9233

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENET X'(in)	RATION Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED MAX.	AREA MIN.
53	0.116591	0.192825	0.058295	0.096412	0.5	0.512536	12.94170	21.40358	0.013612	0.002152
54	0.134529	0.190582	0.067264	0.095291	0.5	0.513424	14.93273	21.15470	0.013462	0.002789
55	0.177130	-0.21237	0.088565	-0.10618	0.5	0.518767	19.66143	-23.5738	0.004093	0.001087
56	-0.02017	0.188340	-0.01008	0.094170	0.5	0.508890	-2.23991	20.90582	0.003794	0.000854
57	0.022421	0.174887	0.011210	0.087443	0.5	0.507712	2.488789	19.41255	0.009507	0.002171
58	0.089686	0.147982	0.044843	0.073991	0.5	0.507430	9.955156	16.42600	0.008975	0.001310
59	0.049327	0.136771	0.024663	0.068385	0.5	0.505257	5.475336	15.18161	0.012964	0.000801
60	0.224215	0.049327	0.112107	0.024663	0.5	0.513007	24.88789	5.475336	0.005556	0.000707
61	0.372197	0.038116	0.186098	0.019058	0.5	0.533850	41.31390	4.230941	0.003457	0.000937
62	-0.04035	-0.02466	-0.02017	-0.01233	0.5	0.500558	-4.47982	-2.73766	0.020742	0.002522
63	0.013452	-0.01121	0.006726	-0.00560	0.5	0.500076	1.493273	-1.24439	0.017501	0.002160
64	0.013452	-0.10986	0.006726	-0.05493	0.5	0.503053	1.493273	-12.1950	0.028521	0.002480
65	0.047085	-0.15695	0.023542	-0.07847	0.5	0.506668	5.226457	-17.4215	0.016205	0.001034
66	0.062780	-0.08295	0.031390	-0.04147	0.5	0.502698	6.968609	-9.20852	0.005364	0.001196
67	-0.08295	-0.16143	-0.04147	-0.08071	0.5	0.508169	-9.20852	-17.9192	0.011815	0.003971
68	-0.08968	-0.03587	-0.04484	-0.01793	0.5	0.502327	-9.95515	-3.98206	0.011667	0.001138
69	-0.04932	0.049327	-0.02466	0.024663	0.5	0.501215	-5.47533	5.475336	0.006222	0.000740
70	0.053811	-0.01569	0.026905	-0.00784	0.5	0.500784	5.973094	-1.74215	0.004093	0.000688
71	0.035874	0.004484	0.017937	0.002242	0.5	0.500326	3.982062	0.497757	0.004321	0.000653
72	0.121076	-0.11883	0.060538	-0.05941	0.5	0.507144	13.43946	-13.1905	0.004861	0.000551
73	-0.21973	-0.11883	-0.10986	-0.05941	0.5	0.515364	-24.3901	-13.1905	0.008187	0.000827
74	-0.21076	-0.15695	-0.10538	-0.07847	0.5	0.516975	-23.3946	-17.4215	0.005691	0.001741
75	-0.20852	-0.01345	-0.10426	-0.00672	0.5	0.510798	-23.1457	-1.49327	0.035738	0.003756
76	-0.17489	-0.03363	-0.08744	-0.01681	0.5	0.507867	-19.4125	-3.73318	0.020469	0.001825
77	-0.16591	0.022421	-0.08295	0.011210	0.5	0.506959	-18.4170	2.488789	0.012281	0.001215
78	-0.15695	-0.06726	-0.07847	-0.03363	0.5	0.507237	-17.4215	-7.46636	0.013334	0.002083
79	-0.18385	-0.13677	-0.09192	-0.06838	0.5	0.512959	-20.4080	-15.1816	0.010371	0.001420
80	-0.15246	0.199551	-0.07623	0.099775	0.5	0.515525	-16.9237	22.15022	0.028657	0.003111
81	-0.11210	0.197309	-0.05605	0.098654	0.5	0.512713	-12.4439	21.90134	0.019014	0.002376
82	0.255605	-0.01793	0.127802	-0.00896	0.5	0.516153	28.37219	-1.99103	0.015556	0.003535
83	0.278026	-0.02914	0.139013	-0.01457	0.5	0.519169	30.86098	-3.23542	0.007071	0.001356
84	0.219730	-0.14798	0.109865	-0.07399	0.5	0.517247	24.39013	-16.4260	0.004093	0.000762
85	0.242152	0.190582	0.121076	0.095291	0.5	0.523201	26.87892	21.15470	0.014404	0.002248
86	0.035874	0.172645	0.017937	0.086322	0.5	0.507713	3.982062	19.16367	0.010676	0.003381
87	0.143497	0.121076	0.071748	0.060538	0.5	0.508736	15.92825	13.43946	0.031113	0.002636
88	0.170403	0.020179	0.085201	0.010089	0.5	0.507307	18.91479	2.239910	0.012964	0.002287
89	0.147982	0.152466	0.073991	0.076233	0.5	0.311161	16.42600	16.92376	0.0164[illegible]	0.002419
90	-0.08744	0.125560	-0.04372	0.062780	0.5	0.505819	-9.70627	13.93721	0.020330	0.003806
91	-0.09417	0.170403	-0.04708	0.085201	0.5	0.509388	-10.4529	18.91479	0.011112	0.002627
92	-0.17713	0.125560	-0.08856	0.062780	0.5	0.511649	-19.6614	13.93721	0.014142	0.001427
93	-0.11883	0.011210	-0.05941	0.005605	0.5	0.503549	-13.1905	1.244394	0.007071	0.001224
94	-0.08520	0.107623	-0.04260	0.053811	0.5	0.504688	-9.45739	11.94618	0.016853	0.003272
95	-0.11883	0.078475	-0.05941	0.039237	0.5	0.505044	-13.1905	8.710762	0.012153	0.001954
96	-0.14125	0.165919	-0.07062	0.082959	0.5	0.511732	-15.6793	18.41704	0.004861	0.000869
97	-0.05381	-0.00896	-0.02690	-0.00448	0.5	0.500743	-5.97309	-0.99551	0.006222	0.001080
98	-0.15246	0.181614	-0.07623	0.090807	0.5	0.513865	-16.9237	20.15919	0.008642	0.001915
99	-0.05829	0.143497	-0.02914	0.071748	0.5	0.505961	-6.47085	15.92825	0.026738	0.002546
100	0.067264	0.201793	0.033632	0.100896	0.5	0.511186	7.466367	22.39910	0.007778	0.000744
101	0.278026	0.156950	0.139013	0.078475	0.5	0.524864	30.86098	17.42152	0.005983	0.000580
102	0.340807	0.147982	0.170403	0.073991	0.5	0.533396	37.82959	16.42600	0.003889	0.000997
103	0.284753	0.038116	0.142376	0.019058	0.5	0.520225	31.60762	4.230941	0.002430	0.000449
104	0.248878	0.020179	0.124439	0.010089	0.5	0.515351	27.62556	2.239910	0.011112	0.001310

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	(IN)² AVG.	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Locations (1-4) Xi	Yi		VEL. (fps)	MV lb-sec -10+-7.5	MV lb-sec -7.5+-5
53	0.007882	8.880731	1019.391	255.5909	637.4910	0.003055	3	99	0	0	0.00E+00	0.00E+00
54	0.008125	11.07567	838.3922	257.4509	547.9215	0.003376	3	99	0	0	0.00E+00	0.00E+00
55	0.002590	7.719282	1069.015	395.6577	732.3366	0.001002	4	-99	0	0	1.00E-03	0.00E+00
56	0.002324	8.603719	995.3428	325.4670	660.4049	0.000904	2	99	0	0	0.00E+00	0.00E+00
57	0.005839	18.83775	550.9646	182.0469	366.5058	0.002760	3	99	0	0	0.00E+00	0.00E+00
58	0.005148	5.833094	1397.637	330.2246	863.9309	0.001774	3	99	0	0	0.00E+00	0.00E+00
59	0.006883	4.358558	1835.575	227.6705	1031.622	0.002118	3	99	0	0	0.00E+00	0.00E+00
60	0.003131	3.193264	2241.757	477.6834	1359.720	0.000930	4	1	4	1359.720	0.00E+00	0.00E+00
61	0.002197	9.102779	962.1598	361.4727	661.8163	0.000906	99	1	0	0	0.00E+00	0.00E+00
62	0.011632	10.31577	916.7991	188.8131	552.8061	0.004541	2	1	2	552.8061	0.00E+00	0.00E+00
63	0.009831	9.154602	1000.747	208.4302	604.5889	0.003725	3	1	3	604.5889	0.00E+00	0.00E+00
64	0.015500	7.096512	1247.273	199.7277	723.5008	0.005448	3	-99	0	0	0.00E+00	0.00E+00
65	0.008619	5.800627	1482.437	188.2538	835.3457	0.002859	3	-99	0	0	0.00E+00	2.86E-03
66	0.003280	6.096493	1278.716	415.0643	846.8906	0.001159	3	-99	0	0	0.00E+00	0.00E+00
67	0.007893	15.20201	607.9642	268.4092	438.1867	0.003600	2	-99	0	0	0.00E+00	3.60E-03
68	0.006403	4.685297	1688.727	294.7927	991.7603	0.002037	2	1	2	991.7603	0.00E+00	0.00E+00
69	0.003481	5.744170	1426.117	289.0319	857.5746	0.001174	2	1	2	857.5746	0.00E+00	0.00E+00
70	0.002391	4.182095	1750.916	459.7499	1105.333	0.000756	3	1	3	1105.333	0.00E+00	0.00E+00
71	0.002487	4.020080	1822.124	441.9489	1132.036	0.000775	3	1	3	1132.036	0.00E+00	0.00E+00
72	0.002706	3.694667	2010.716	393.1211	1201.918	0.000822	3	-99	0	0	0.00E+00	0.00E+00
73	0.004507	4.436872	1789.010	320.6710	1054.840	0.001444	1	-99	0	0	0.00E+00	0.00E+00
74	0.003716	8.072098	1007.178	414.3486	710.7638	0.001459	1	-99	0	0	0.00E+00	1.46E-03
75	0.019747	8.608562	1078.023	199.0089	638.5162	0.007431	1	1	1	638.5162	0.00E+00	0.00E+00
76	0.011147	8.970384	1052.124	171.7305	611.9275	0.004189	1	1	1	611.9275	0.00E+00	0.00E+00
77	0.006748	4.445373	1767.082	311.7785	1039.430	0.002134	1	1	1	1039.430	0.00E+00	0.00E+00
78	0.007709	7.783091	1118.019	277.8525	697.9360	0.002867	2	-99	0	0	0.00E+00	0.00E+00
79	0.005896	6.784250	1265.649	284.9845	775.3170	0.002123	1	-99	0	0	0.00E+00	2.12E-03
80	0.015884	8.813649	1064.001	201.2467	632.6240	0.006063	2	99	0	0	0.00E+00	0.00E+00
81	0.010695	10.2848	933.4447	196.2325	564.8386	0.004253	2	99	0	0	0.00E+00	0.00E+00
82	0.009546	16.76041	609.3383	200.5714	404.9548	0.004436	4	1	4	404.9548	0.00E+00	0.00E+00
83	0.004214	7.119089	1189.018	344.6892	766.8539	0.001575	4	1	4	766.8539	0.00E+00	0.00E+00
84	0.002428	8.236339	1066.665	302.4428	684.5542	0.000937	4	-99	0	0	0.00E+00	9.37E-04
85	0.008326	6.005037	1390.180	345.1909	867.8855	0.002970	4	99	0	0	0.00E+00	0.00E+00
86	0.007029	9.958548	843.5848	356.1943	599.8896	0.002875	3	99	0	0	0.00E+00	0.00E+00
87	0.016875	4.74065	1704.662	267.7797	986.3209	0.005402	3	99	0	0	0.00E+00	0.00E+00
88	0.007625	6.55656	1255.176	341.7504	798.4634	0.002733	4	1	4	798.4634	0.00E+00	0.00E+00
89	0.009459	7.399674	1175.236	278.5312	726.8839	0.003433	3	99	0	0	0.00E+00	0.00E+00
90	0.012068	19.05821	558.7616	159.0432	358.9024	0.005651	2	99	0	0	0.00E+00	0.00E+00
91	0.006863	7.278041	1121.579	380.3492	750.9614	0.002570	2	99	0	0	0.00E+00	0.00E+00
92	0.007784	5.138114	1594.059	285.4165	939.7379	0.002573	1	99	0	0	0.00E+00	0.00E+00
93	0.004143	4.821431	1575.094	422.9322	999.0132	0.001367	2	1	2	999.0132	0.00E+00	0.00E+00
94	0.010062	12.91871	743.4406	217.4657	480.4531	0.004276	2	99	0	0	0.00E+00	0.00E+00
95	0.007054	7.088052	1191.864	302.6562	747.2603	0.002558	2	99	0	0	0.00E+00	0.00E+00
96	0.002865	6.980015	1203.683	330.9290	767.3060	0.001050	2	99	0	0	0.00E+00	0.00E+00
97	0.003651	5.477112	1425.110	383.2937	904.2022	0.001238	2	1	2	904.2022	0.00E+00	0.00E+00
98	0.005279	9.470932	935.0173	302.0695	618.5434	0.002117	2	99	0	0	0.00E+00	0.00E+00
99	0.014642	7.512375	1193.487	204.6096	699.0488	0.005264	2	99	0	0	0.00E+00	0.00E+00
100	0.004261	4.693282	1711.015	294.3857	1002.700	0.001373	3	99	0	0	0.00E+00	0.00E+00
101	0.003281	3.046959	2410.850	419.0821	1414.966	0.000958	4	99	0	0	0.00E+00	0.00E+00
102	0.002443	4.092930	1766.474	636.5154	1201.495	0.000822	99	99	0	0	0.00E+00	0.00E+00
103	0.001440	6.943494	1218.633	343.7171	781.1754	0.000534	4	1	4	781.1754	0.00E+00	0.00E+00
104	0.006211	4.829721	1659.606	334.0832	996.8450	0.002047	4	1	4	996.8450	0.00E+00	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -5+-2.5	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+10
53	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E-03
54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.38E-03
55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.04E-04
57	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-03	0.00E+00
58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-03	0.00E+00
59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E-03	0.00E+00
60	0.00E+00	0.00E+00	0.00E+00	9.31E-04	0.00E+00	0.00E+00	0.00E+00
61	0.00E+00	0.00E+00	9.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
62	0.00E+00	0.00E+00	4.54E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
63	0.00E+00	0.00E+00	3.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	5.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
66	0.00E+00	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
68	0.00E+00	0.00E+00	2.04E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69	0.00E+00	0.00E+00	0.00E+00	1.17E-03	0.00E+00	0.00E+00	0.00E+00
70	0.00E+00	0.00E+00	7.57E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71	0.00E+00	0.00E+00	7.75E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
72	8.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
73	1.44E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
74	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	0.00E+00	0.00E+00	7.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
76	0.00E+00	0.00E+00	4.19E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
77	0.00E+00	0.00E+00	2.13E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
78	0.00E+00	2.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
79	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.06E-03
81	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E-03
82	0.00E+00	0.00E+00	4.44E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
83	0.00E+00	0.00E+00	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-03
86	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-03	0.00E+00
87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-03	0.00E+00	0.00E+00
88	0.00E+00	0.00E+00	2.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.48E-03	0.00E+00
90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.65E-03	0.00E+00	0.00E+00
91	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00
92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-03	0.00E+00	0.00E+00
93	0.00E+00	0.00E+00	1.37E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-03	0.00E+00	0.00E+00
95	0.00E+00	0.00E+00	0.00E+00	2.56E-03	0.00E+00	0.00E+00	0.00E+00
96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-03	0.00E+00
97	0.00E+00	0.00E+00	1.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
98	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E-03
99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.26E-03	0.00E+00
100	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-03
101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.59E-04	0.00E+00
102	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.23E-04	0.00E+00
103	0.00E+00	0.00E+00	5.35E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
104	0.00E+00	0.00E+00	2.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
105	1	71	26.25	0.01	0.117	0.103	0.019	1.135922	23	2.25	111.5	113.8697
106	1	63	20	0.07	0.242	0.109	0.045	2.220183	15	-4	111.5	112.5755
107	1	67	12.5	0.08	0.318	0.166	0.018	1.915662	19	-11.5	111.5	113.6903
108	1	65	5.5	0.02	0.129	0.13	0.029	0.992307	17	-18.5	111.5	114.2956
109	2	7.5	8.5	0.16	0.305	0.131	0.088	2.328244	-40.5	-15.5	112	120.1020
110	2	11	8	0.29	0.453	0.227	0.051	1.995594	-37	-16	112	119.0336
111	2	14	8	0.31	0.3	0.206	0.085	1.456310	-34	-16	112	118.1355
112	2	21.5	8.5	0.15	0.302	0.151	0.096	2	-36.5	-15.5	112	116.1313
113	2	27.5	45.25	0.1	0.291	0.195	0.176	1.492307	-20.5	21.25	112	115.8266
114	2	29.5	10	0.28	0.361	0.198	0.06	1.823232	-18.5	-14	112	114.3776
115	2	29.25	44.25	0.01	0.146	0.088	0.027	1.659090	-18.75	20.25	112	115.3500
116	2	34.5	41.25	0.77	0.503	0.236	0.103	2.131355	-13.5	17.25	112	114.1219
117	2	45	40	0.04	0.21	0.139	0.059	1.510791	-3	16	112	113.1768
118	2	57	34	0.01	0.21	0.07	0.039	3	9	10	112	112.8051
119	2	69	5	0.09	0.328	0.149	0.032	2.201342	21	-19	112	115.5248
120	2	74	1	0.17	0.31	0.226	0.059	1.371681	26	-23	112	117.2561
121	2	68	17	0.06	0.217	0.186	0.039	1.166666	20	-7	112	113.9868
122	2	71.5	36.5	0.01	0.376	0.033	0.005	11.39393	23.5	12.5	112	115.1195
123	2	13.5	44.5	0.18	0.422	0.179	0.048	2.357541	-34.5	20.5	112	118.9726
124	2	15.5	20	0.03	0.143	0.104	0.033	1.375	-32.5	-4	112	116.6886
125	2	22.5	9	0.03	0.174	0.127	0.031	1.370078	-25.5	-15	112	115.8414
126	2	20.5	30	0.71	0.48	0.305	0.09	1.573770	-27.5	6	112	115.4826
127	2	26	27.5	0.03	0.13	0.109	0.035	1.192660	-22	3.5	112	114.1939
128	2	28.5	40	0.43	0.494	0.198	0.036	2.494949	-19.5	16	112	114.8052
129	2	33	45	0.05	0.214	0.172	0.024	1.244186	-15	21	112	114.9347
130	3	41.5	30	0.16	0.316	0.196	0.057	1.612244	-6.5	6	112.5	112.8472
131	3	38	45.75	0.01	0.121	0.077	0.024	1.571428	-10	21.75	112.5	115.0187
132	3	49	10.75	0.05	0.184	0.17	0.036	1.082352	1	-13.25	112.5	[illegible]
133	3	48	38.5	0.07	0.259	0.158	0.034	1.639240	0	14.5	112.5	113.4305
134	3	47	28	0.01	0.128	0.11	0.024	1.163636	-1	4	112.5	112.5755
135	3	61	28.25	1.42	0.603	0.4	0.129	1.5075	13	4.25	112.5	113.3283
136	3	52.75	40	0.02	0.199	0.122	0.023	1.631147	4.75	16	112.5	113.7313
137	3	63.5	37.5	0.17	[illegible]	0.207	0.049	1.444444	15.5	13.5	112.5	114.3623
138	3	64.5	40	0.1	[illegible]	0.178	0.031	1.634831	16.5	16	112.5	114.8237
139	3	66	15	0.06	0.155	0.125	0.039	1.24	18	-9	112.5	114.2858
140	3	77	39.5	0.02	0.158	0.078	0.032	2.025641	29	15.5	112.5	117.2070
141	3	79	38.5	0.11	0.295	0.142	0.082	2.077464	31	14.5	112.5	117.5903
142	3	79	23.5	0.01	0.166	0.103	0.028	1.611650	31	-0.5	112.5	116.6940
143	3	82	37.75	0.1	0.203	0.168	0.09	1.208333	34	13.75	112.5	118.3271
144	3	1	43	0.07	0.217	0.141	0.031	1.539007	-47	19	112.5	123.3946
145	3	38.5	35.5	0.03	0.238	0.066	0.03	3.606060	-9.5	11.5	112.5	113.4845
146	3	34	22	0.01	0.113	0.082	0.015	1.378048	-14	-2	112.5	113.3854
147	4	24.5	39	0.2	0.373	0.194	0.064	1.922680	-23.5	15	113	116.3883
148	4	50.5	38.5	0.02	0.171	0.08	0.031	2.1375	2.5	14.5	113	[illegible]
149	4	63.5	25.25	0.06	0.337	0.192	0.028	1.755208	15.5	1.25	113	114.0649
150	4	76	23.5	0.12	0.316	0.142	0.053	2.225352	28	-0.5	113	116.4194
151	4	80	20	0.06	0.245	0.114	0.051	2.149122	32	-4	113	117.5117
152	4	81	32	0.17	0.261	0.25	0.046	1.044	33	8	113	117.9915
153	5	12	38	0.19	0.3	0.288	0.035	1.041666	-36	14	113.5	119.8926
154	5	32	47.5	0.06	0.22	0.107	0.057	2.056074	-16	23.5	113.5	117.0064
155	5	69	17	0.07	0.189	0.11	0.052	1.718181	21	-7	113.5	115.6384
156	5	67.5	43.5	0.07	0.328	0.131	0.051	2.503816	19.5	19.5	113.5	116.8021

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENET RATION X'(in)	Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED MAX.	AREA MIN.
105	0.206278	0.020179	0.103139	0.010089	0.5	0.510626	22.89686	2.239910	0.004093	0.000664
106	0.134529	-0.03587	0.067264	-0.01793	0.5	0.504823	14.93273	-3.98206	0.012099	0.002249
107	0.170403	-0.10313	0.085201	-0.05156	0.5	0.509822	18.91479	-11.4484	0.034570	0.001956
108	0.152466	-0.16591	0.076233	-0.08295	0.5	0.512536	16.52376	-18.4170	0.005364	0.001205
109	-0.36160	-0.13839	-0.36160	-0.13839	1	1.072339	-40.1383	-15.3616	0.014142	0.004080
110	-0.33035	-0.14285	-0.33035	-0.14285	1	1.062800	-36.6696	-15.8571	0.044230	0.004979
111	-0.30357	-0.14285	-0.30357	-0.14285	1	1.054781	-33.6964	-15.8571	0.028368	0.008037
112	-0.23660	-0.13839	-0.23660	-0.13839	1	1.036887	-26.2633	-15.3616	0.012153	0.003863
113	-0.18303	0.189732	-0.18303	0.189732	1	1.034166	-20.3169	21.06026	0.004419	0.002673
114	-0.16517	-0.125	-0.16517	-0.125	1	1.021229	-18.3348	-13.875	0.036299	0.006033
115	-0.16741	0.180803	-0.16741	0.180803	1	1.029910	-18.5825	20.06919	0.002880	0.000532
116	-0.12053	0.154017	-0.12053	0.154017	1	1.018945	-13.3794	17.09598	0.058149	0.011907
117	-0.02678	0.142857	-0.02678	0.142857	1	1.010507	-2.97321	15.85714	0.005761	0.001481
118	0.080357	0.089285	0.080357	0.089285	1	1.007188	8.919642	9.910714	0.001994	0.000370
119	0.1875	-0.16964	0.1875	-0.16964	1	1.031472	20.8125	-18.8303	0.021876	0.002134
120	0.232142	-0.20535	0.232142	-0.20535	1	1.046929	25.76785	-22.7946	0.022412	0.004265
121	0.178571	-0.0625	0.178571	-0.0625	1	1.017739	19.82142	-6.9375	0.011966	0.002150
122	0.209821	0.111607	0.209821	0.111607	1	1.027352	23.29017	12.38839	0.015556	0.000206
123	-0.30803	0.183035	-0.30803	0.183035	1	1.062256	-34.1919	20.31696	0.029169	0.003317
124	-0.29017	-0.03571	-0.29017	-0.03571	1	1.041863	-32.2098	-3.96428	0.007071	0.001631
125	-0.22767	-0.13392	-0.22767	-0.13392	1	1.034298	-25.2723	-14.8660	0.007527	0.001341
126	-0.24553	0.053571	-0.24553	0.053571	1	1.031095	-27.2544	5.946428	0.061363	0.011505
127	-0.19642	0.03125	-0.19642	0.03125	1	1.019588	-21.8035	3.46875	0.006667	0.001795
128	-0.17410	0.142857	-0.17410	0.142857	1	1.025047	-19.3258	15.85714	0.038892	0.006770
129	-0.13392	0.1875	-0.13392	0.1875	1	1.026203	-14.8660	20.8125	0.016205	0.001817
130	-0.05777	0.053333	-0.08666	0.08	1.5	1.504629	-6.41333	5.92	0.021834	0.003938
131	-0.08888	0.193333	-0.13333	0.29	1.5	1.533583	-9.86666	21.46	0.003241	0.000642
132	0.008888	-0.11777	0.013333	-0.17666	1.5	1.510426	0.986666	-13.0733	0.010803	0.002113
133	0	0.128888	0	0.193333	1.5	1.512407	0	14.30666	0.016014	0.002102
134	-0.00889	0.035555	-0.01333	0.053333	1.5	1.501007	-0.98666	3.946666	0.003241	0.000607
135	0.115555	0.037777	0.173333	0.056666	1.5	1.511044	12.82666	4.193333	0.085623	0.018317
136	0.042222	0.142222	0.063333	0.213333	1.5	1.516417	4.686666	15.78666	0.006763	0.000781
137	0.137777	0.12	0.206666	0.18	1.5	1.524831	15.29333	13.32	0.026986	0.004422
138	0.146666	0.142222	0.22	0.213333	1.5	1.530983	16.28	15.78666	0.025091	0.002673
139	0.16	-0.08	0.24	-0.12	1.5	1.523811	17.76	-8.88	0.011966	0.003011
140	0.257777	0.137777	0.386666	0.206666	1.5	1.562761	28.61333	15.29333	0.004861	0.000984
141	0.275555	0.128888	0.413333	0.193333	1.5	1.567871	30.58666	14.30666	0.010434	0.002900
142	0.275555	-0.00444	0.413333	-0.00666	1.5	1.555920	30.58666	-0.49333	0.002778	0.000468
143	0.302222	0.122222	0.453333	0.183333	1.5	1.577695	33.54666	13.56666	0.008642	0.003831
144	-0.41777	0.168888	-0.62666	0.253333	1.5	1.645262	-46.3733	18.74666	0.017564	0.002509
145	-0.08444	0.102222	-0.12666	0.153333	1.5	1.513127	-9.37333	11.34666	0.007778	0.000980
146	-0.12444	-0.01777	-0.18666	-0.02666	1.5	1.511805	-13.8133	-1.97333	0.005185	0.000688
147	-0.20796	0.132743	-0.41592	0.265486	2	2.059970	-23.0840	14.73451	0.024307	0.004170
148	0.022123	0.128318	0.044247	0.256637	2	2.016883	2.455752	14.24336	0.005018	0.000909
149	0.137168	0.011061	0.274336	0.022123	2	2.018848	15.22566	1.227876	0 016668	0.001384
150	0.247787	-0.00442	0.495575	-0.00884	2	2.060503	27.50442	-0.49115	0.017611	0.002953
151	0.283185	-0.03539	0.566371	-0.07079	2	2.079853	31.43362	-3.92920	0.009151	0.001904
152	0.292035	0.070796	0.584070	0.141592	2	2.088345	32.41592	7.858407	0.028746	0.005066
153	-0.31718	0.123348	-0.79295	0.308370	2.5	2.640807	-35.2070	13.69162	0.017387	0.004926
154	-0.14096	0.207048	-0.35242	0.517621	2.5	2.577283	-15.6475	22.98297	0.008187	0.002121
155	0.185022	-0.06167	0.462555	-0.15418	2.5	2.547102	20.53744	-6.84581	0.010471	0.002380
156	0.171806	0.171806	0.429515	0.429515	2.5	2.572785	19.07048	19.07048	0.010676	0.001660

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	(IN^2) AVG.	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen X1	Locations Y1	(1-4)	VEL. (fps)	MV lb-sec -10+-7.5	MV lb-sec -7.5+-5
105	0.002379	4.202777	1776.660	454.4962	1115.578	0.000763	4	1	4	1115.578	0.00E+00	0.00E+00
106	0.007174	9.756225	922.6502	261.2672	591.9587	0.002837	3	1	3	591.9587	0.00E+00	0.00E+00
107	0.018263	4.380222	1647.999	214.4548	1031.227	0.005648	4	-99	0	0	0.00E+00	0.00E+00
108	0.003285	6.087885	1297.440	423.5878	860.5140	0.001178	3	-99	0	0	0.00E+00	1.18E-03
109	0.009111	17.56005	981.7015	386.4706	684.0860	0.007493	-99	-99	0	0	0.00E+00	7.49E-03
110	0.024605	11.78619	1468.091	285.3363	876.7140	0.017407	-99	-99	0	0	0.00E+00	1.74E-02
111	0.019203	17.03002	995.1757	386.4754	690.8261	0.014662	1	-99	0	0	0.00E+00	1.47E-02
112	0.008008	18.72970	996.7831	379.6519	638.2175	0.006554	1	-99	0	0	0.00E+00	6.55E-03
113	0.003546	28.19841	568.0692	389.5[illegible]6	478.8324	0.003273	1	99	0	0	0.00E+00	0.00E+00
114	0.021166	13.22854	1261.307	328.3251	794.8164	0.015236	1	-99	0	0	0.00E+00	0.00E+00
115	0.001706	5.858769	2310.303	651.5191	1480.911	0.001013	1	99	0	0	0.00E+00	0.00E+00
116	0.035038	21.98206	839.6098	255.5815	547.5956	0.028868	2	99	0	0	0.00E+00	0.00E+00
117	0.003621	11.04447	1354.258	489.0264	921.6423	0.002524	2	99	0	0	0.00E+00	0.00E+00
118	0.001182	8.457079	1724.355	487.8213	1106.088	0.000757	3	99	0	0	0.00E+00	0.00E+00
119	0.012005	7.496476	2036.211	355.4511	1195.831	0.007368	4	-99	0	0	0.00E+00	7.37E-03
120	0.013339	12.74451	1301.341	374.9807	838.1611	0.009755	4	-99	0	0	9.76E-03	0.00E+00
121	0.907058	8.500025	1737.885	479.7056	1108.795	0.004554	4	-99	0	0	0.00E+00	0.00E+00
122	0.007881	1.268728	8171.707	319.9995	4245.853	0.002906	4	99	0	0	0.00E+00	0.00E+00
123	0.016243	11.08132	1535.794	300.8013	918.2979	0.011316	1	99	0	0	0.00E+00	0.00E+00
124	0.004351	6.89403	2004.770	667.4952	1336.133	0.002744	1	1	1	1336.133	0.00E+00	0.00E+00
125	0.004434	6.765391	2089.562	573.0133	1331.288	0.002734	1	-99	0	0	0.00E+00	2.73E-03
126	0.036434	19.48698	937.3124	267.0762	602.1943	0.029272	1	1	1	602.1943	0.00E+00	0.00E+00
127	0.004231	7.090278	1887.381	705.4290	1296.405	0.002662	1	1	1	1296.405	0.00E+00	0.00E+00
128	0.022831	18.83559	965.5530	260.2284	612.8907	0.018043	1	99	0	0	0.00E+00	0.00E+00
129	0.009011	5.548606	2516.858	487.7607	1502.309	0.005142	2	99	0	0	0.00E+00	0.00E+00
130	0.012886	12.41620	1752.904	485.1757	1119.040	0.012258	2	1	2	1119.040	0.00E+00	0.00E+00
131	0.001941	5.149492	3401.842	1011.075	2206.459	0.001510	2	99	0	0	0.00E+00	0.00E+00
132	0.006458	7.741649	2481.361	729.9674	1605.664	0.005496	3	-99	0	0	0.00E+00	0.00E+00
133	0.009058	7.727640	2592.594	565.4172	1579.006	0.007567	3	99	0	0	0.00E+00	0.00E+00
134	0.001924	5.196530	3347.501	953.8316	2150.666	0.001472	2	1	2	2150.666	0.00E+00	0.00E+00
135	0.051970	27.32321	953.0326	299.7865	626.4096	0.060900	3	1	3	626.4096	0.00E+00	0.00E+00
136	0.003772	5.301073	3482.654	690.3453	2086.499	0.002857	3	99	0	0	0.00E+00	0.00E+00
137	0.015704	10.82489	1983.176	510.8049	1246.990	0.014513	3	99	0	0	0.00E+00	0.00E+00
138	0.013892	7.203352	2804.134	522.8779	1663.506	0.011389	3	99	0	0	0.00E+00	0.00E+00
139	0.007488	8.011806	2352.296	835.6832	1593.989	0.006547	3	-99	0	0	0.00E+00	0.00E+00
140	0.002923	6.842098	2780.667	839.4962	1810.081	0.002478	4	99	0	0	0.00E+00	0.00E+00
141	0.006667	16.48796	1376.304	526.8761	951.5905	0.007166	4	99	0	0	0.00E+00	0.00E+00
142	0.001623	6.160277	3063.473	806.3092	1934.891	0.001324	4	1	4	1934.891	0.00E+00	0.00E+00
143	0.006237	16.03270	1289.518	700.6279	995.0732	0.006812	4	99	0	0	0.00E+00	0.00E+00
144	0.010036	6.47438	2959.647	687.7341	1823.718	0.008740	-99	99	0	0	0.00E+00	0.00E+00
145	0.004379	6.850137	2848.773	602.6513	1725.712	0.003544	2	99	0	0	0.00E+00	0.00E+00
146	0.002937	3.404831	4787.905	1052.943	2920.424	0.001999	2	1	2	2920.424	0.00E+00	0.00E+00
147	0.014239	14.04569	2034.009	542.2584	1288.133	0.017638	1	99	0	0	0.00E+00	0.00E+00
148	0.002964	6.747490	3448.113	957.9784	2203.045	0.003016	3	99	0	0	0.00E+00	0.00E+00
149	0.009026	6.647080	3724.358	576.3649	2150.361	0.008833	3	1	3	2150.361	0.00E+00	0.00E+00
150	0.010282	11.67004	2343.501	614.1957	1478.848	0.012149	4	1	4	1478.848	0.00E+00	0.00E+00
151	0.005528	10.85376	2429.064	748.5866	1588.825	0.006526	4	1	4	1588.825	0.00E+00	0.00E+00
152	0.016906	10.05531	2632.543	716.0832	1674.313	0.019487	4	99	0	0	0.00E+00	0.00E+00
153	0.011156	17.03002	1980.755	769.2256	1374.989	0.017086	1	99	0	0	0.00E+00	0.00E+00
154	0.005154	11.64001	2624.528	953.1044	1788.816	0.007348	2	99	0	0	0.00E+00	0.00E+00
155	0.006675	10.48537	2786.919	1058.718	1922.819	0.009215	4	-99	0	0	0.00E+00	0.00E+00
156	0.006168	11.34855	2849.120	705.4773	1777.298	0.008517	4	99	0	0	0.00E+00	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -5+-2.5	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+10
105	0.00E+00	0.00E+00	7.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
106	0.00E+00	0.00E+00	2.84E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
107	5.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
108	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
111	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
112	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
113	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.28E-03
114	1.52E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
115	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-03
116	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.89E-02	0.00E+00
117	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.52E-03	0.00E+00
118	0.00E+00	0.00E+00	0.00E+00	7.57E-04	0.00E+00	0.00E+00	0.00E+00
119	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
121	0.00E+00	4.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-03	0.00E+00	0.00E+00
123	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-02
124	0.00E+00	0.00E+00	2.74E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
126	0.00E+00	0.00E+00	0.00E+00	2.93E-02	0.00E+00	0.00E+00	0.00E+00
127	0.00E+00	0.00E+00	2.66E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
128	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-02	0.00E+00
129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.14E-03
130	0.00E+00	0.00E+00	0.00E+00	1.23E-02	0.00E+00	0.00E+00	0.00E+00
131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-03
132	5.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.57E-03	0.00E+00	0.00E+00
134	0.00E+00	0.00E+00	1.47E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
135	0.00E+00	0.00E+00	6.09E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
136	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-03	0.00E+00
137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-02	0.00E+00	0.00E+00
138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-02	0.00E+00
139	0.00E+00	6.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.48E-03	0.00E+00
141	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.17E-03	0.00E+00	0.00E+00
142	0.00E+00	0.00E+00	1.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.81E-03	0.00E+00	0.00E+00
144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.74E-03	0.00E+00
145	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E-03	0.00E+00	0.00E+00
146	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
147	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-02	0.00E+00	0.00E+00
148	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-03	0.00E+00	0.00E+00
149	0.00E+00	0.00E+00	8.83E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
150	0.00E+00	0.00E+00	1.21E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
151	0.00E+00	0.00E+00	6.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
152	0.00E+00	0.00E+00	0.00E+00	1.95E-02	0.00E+00	0.00E+00	0.00E+00
153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-02	0.00E+00	0.00E+00
154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.35E-03
155	0.00E+00	9.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
156	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.57E-03	0.00E+00

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
157	5	80	47.5	0.02	0.102	0.081	0.024	1.259259	32	23.5	113.5	120.2435
158	6	42	22.5	0.36	0.406	0.254	0.044	1.598425	-6	-1.5	114	114.1676
159	6	61	40.25	0.18	0.35	0.159	0.045	2.201257	13	16.25	114	115.8838
160	6	58	43.75	0.22	0.321	0.235	0.054	1.365957	10	19.75	114	116.1295
161	6	40.25	33	0.06	0.129	0.1	0.055	1.29	-7.75	9	114	114.6170
162	7	5	32.5	0.41	0.596	0.186	0.046	3.204301	-43	8.5	114.5	122.6030
163	7	28.5	46	0.18	0.312	0.2	0.049	1.56	-19.5	22	114.5	118.2137
164	7	59.5	44.75	0.1	0.296	0.146	0.053	2.027397	11.5	20.75	114.5	116.9318
165	8	34	42.5	0.13	0.288	0.175	0.077	1.645714	-14	18.5	115	117.3168
166	9	4	47	0.24	0.326	0.278	0.056	1.172661	-44	23	115.5	125.7189
167	9	78.5	40.25	0.05	0.145	0.125	0.049	1.16	30.5	16.25	115.5	120.5593
168	10	70.25	46	0.3	0.512	0.146	0.047	3.506849	22.25	22	116	120.1460
169	11	15	1	0.27	0.369	0.246	0.043	1.5	-33	-23	116.5	123.2487
170	12	23.5	1	0.1	0.333	0.213	0.026	1.563380	-24.5	-23	117	121.7302
171	12	60	32	0.25	0.345	0.168	0.049	2.053571	12	8	117	117.8855
172	1	70	12.5	0.08	0.267	0.132	0.032	2.022727	22	-11.5	111.5	114.2300
173	1	79	6.5	0.01	0.108	0.073	0.031	1.479452	31	-17.5	111.5	117.0448
174	1	45.75	45	0.01	0.198	0.175	0.019	1.131428	-2.25	21	111.5	113.4826
175	1	42.5	29.5	0.02	0.151	0.07	0.02	2.157142	-5.5	5.5	111.5	111.7709
176	1	35.5	46	0.08	0.271	0.184	0.03	1.472826	-12.5	22	111.5	114.3350

Total Mass = 17.43

Total Impulse Over Target at 9 ft. (4x8 Sheet)= 1.288192 lb-sec

Average Specific Impulse (at center)= 0.297099 psi-ms

(based on curved target surface calculation)

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENET X'(in)	RATION Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED MAX.	AREA MIN.
157	0.281938	0.207048	0.704845	0.517621	2.5	2.648535	31.29515	22.98237	0.006482	0.001525
158	-0.05263	-0.01315	-0.15789	-0.03947	3	3.004411	-5.84210	-1.46052	0.063642	0.006897
159	0.114035	0.142543	0.342105	0.427631	3	3.049574	12.65789	15.82236	0.031113	0.004000
160	0.087719	0.173245	0.263157	0.519736	3	3.056039	9.736842	19.23026	0.031690	0.005331
161	-0.06798	0.078947	-0.20394	0.236842	3	3.016237	-7.54605	8.763157	0.008485	0.003617
162	-0.37554	0.074235	-1.31441	0.259825	3.5	3.747690	-41.6855	8.240174	0.069329	0.005350
163	-0.17030	0.192139	-0.59606	0.672489	3.5	3.613521	-18.9039	21.32751	0.028573	0.004487
164	0.100436	0.181222	0.351528	0.634279	3.5	3.574336	11.14847	20.11572	0.014676	0.002627
165	-0.12173	0.160869	-0.48695	0.643478	4	4.080587	-13.5130	17.85652	0.013132	0.003511
166	-0.38095	0.199134	-1.71428	0.896103	4.5	4.898140	-42.2857	22.10389	0.033336	0.005726
167	0.264069	0.140692	1.188311	0.633116	4.5	4.697118	29.31168	15.61688	0.007937	0.002682
168	0.191810	0.189655	0.959051	0.948275	5	5.178707	21.29094	21.05172	0.049649	0.004557
169	-0.28326	-0.19742	-1.55793	-1.08583	5.5	5.818609	-31.4420	-21.9141	0.048841	0.005691
170	-0.20940	-0.19658	-1.25641	-1.17948	6	6.242576	-23.2435	-21.8205	0.029917	0.002335
171	0.102564	0.068376	0.615384	0.410256	6	6.045412	11.38461	7.589743	0.039686	0.005636
172	0.197309	-0.10313	0.098654	-0.05156	0.5	0.512242	21.90134	-11.4484	0.019446	0.002330
173	0.278026	-0.15695	0.139013	-0.07847	0.5	0.524864	30.86098	-17.4215	0.002509	0.000720
174	-0.02017	0.188340	-0.01008	0.094170	0.5	0.508390	-2.23991	20.90582	0.004093	0.000392
175	-0.04932	0.049327	-0.02466	0.024663	0.5	0.501215	-5.47533	5.475336	0.007778	0.001030
176	-0.11210	0.197309	-0.05605	0.098654	0.5	0.512713	-12.4439	21.90134	0.020742	0.002296

Total Imp

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	(IN)² AVG.	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Xi	Locations Yi	(1-4)	VEL. (fps)	MV lb-sec -10+-7.5	MV lb-sec -7.5+-5
157	0.004003	4.995474	5124.931	1731.395	3428.163	0.004694	4	99	0	0	0.00E+00	0.00E+00
158	0.035269	10.20709	3575.379	675.3317	2125.355	0.052384	2	1	2	2125.355	0.00E+00	0.00E+00
159	0.017557	10.25225	3555.184	763.3444	2159.264	0.026610	3	99	0	0	0.00E+00	0.00E+00
160	0.018510	11.88511	3105.746	815.7979	1960.772	0.029533	3	99	0	0	0.00E+00	0.00E+00
161	0.006051	9.914491	3033.327	1600.475	2316.901	0.009517	2	99	0	0	0.00E+00	0.00E+00
162	0.037340	10.98006	4081.751	597.6958	2339.723	0.065677	-99	99	0	0	0.00E+00	0.00E+00
163	0.016530	10.88878	3787.852	944.9834	2366.418	0.029163	1	99	0	0	0.00E+00	0.00E+00
164	0.008652	11.55787	3542.271	975.0344	2258.652	0.015463	3	99	0	0	0.00E+00	0.00E+00
165	0.008321	15.62162	2956.419	1099.233	2027.826	0.018048	2	99	0	0	0.00E+00	0.00E+00
166	0.019531	12.28791	4305.013	1148.688	2726.851	0.044806	-99	99	0	0	0.00E+00	0.00E+00
167	0.005309	9.416688	4611.250	2043.806	3327.528	0.011391	4	99	0	0	0.00E+00	0.00E+00
168	0.027103	11.06857	5118.995	853.7007	2986.348	0.061338	4	99	0	0	0.00E+00	0.00E+00
169	0.027266	9.902240	5971.799	1191.068	3581.434	0.066205	1	-99	0	0	6.62E-02	0.00E+00
170	0.016126	6.200960	9180.894	1356.069	5268.482	0.036070	1	-99	0	0	3.61E-02	0.00E+00
171	0.022661	11.03201	5572.043	1289.131	3430.587	0.058719	3	99	0	0	0.00E+00	0.00E+00
172	0.010888	7.347268	1204.581	245.3664	724.9740	0.003970	4	-99	0	0	0.00E+00	0.00E+00
173	0.001614	6.193077	1256.337	492.6743	874.5061	0.000598	4	-99	0	0	0.00E+00	5.99E-04
174	0.002243	4.457536	1772.129	305.5355	1038.832	0.000711	2	99	0	0	0.00E+00	0.00E+00
175	0.004404	4.540949	1685.923	370.1498	1028.036	0.001407	2	1	2	1028.036	0.00E+00	0.00E+00
176	0.011519	6.944802	1265.193	242.8124	754.0031	0.004129	2	99	0	0	0.00E+00	0.00E+00
Total Imp											0.138	0.084

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -5+-2.5	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+10
157	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.69E-03
158	0.00E+00	0.00E+00	5.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
159	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-02	0.00E+00
160	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-02	0.00E+00
161	0.00E+00	0.00E+00	0.00E+00	9.52E-03	0.00E+00	0.00E+00	0.00E+00
162	0.00E+00	0.00E+00	0.00E+00	6.57E-02	0.00E+00	0.00E+00	0.00E+00
163	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-02
164	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-02
165	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-02	0.00E+00
166	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E-02
167	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-02	0.00E+00
168	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E-02
169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
170	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
171	0.00E+00	0.00E+00	0.00E+00	5.87E-02	0.00E+00	0.00E+00	0.00E+00
172	3.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
173	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
174	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.11E-04
175	0.00E+00	0.00E+00	0.00E+00	1.41E-03	0.00E+00	0.00E+00	0.00E+00
176	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-03
Total Imp	0.057	0.043	0.211	0.208	0.104	0.214	0.227

(The reverse side of this page is blank.)

APPENDIX F

Fragment Data from the 2.4 Pound Cased Charge Test

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST.

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
1	30	47.25	1	5.71	1.038	0.559	0.187	1.856887	-0.75	-23	126	128.0842
2	29	94.5	17.5	4.19	1.769	1.524	1.216	1.160761	46.5	-6.5	125.5	133.9953
3	27	52	11.5	7.06	0.865	0.6	0.211	1.441666	4	-12.5	124.5	125.1898
4	27	14	2.75	1.75	0.659	0.295	0.174	2.233898	-34	-21.25	124.5	130.7968
5	27	49	29	7.3	1.141	0.469	0.263	2.432835	1	5	124.5	124.6043
6	26	95	17.5	2.85	0.718	0.442	0.194	1.624434	47	-6.5	124	132.7676
7	26	49	18	10.88	1.15	0.694	0.23	1.657060	1	-6	124	124.1491
8	25	51.25	10.5	0.64	0.382	0.259	0.105	1.474903	3.25	-13.5	123.5	124.2781
9	22	60	12.5	4.5	0.789	0.295	0.145	2.674576	12	-11.5	122	123.1269
10	21	24	4	4.28	0.861	0.475	0.244	1.812631	-24	-20	121.5	125.4521
11	21	62	31	3.6	0.724	0.407	0.211	1.778869	14	7	121.5	122.5040
12	20	78	3	3.25	0.655	0.435	0.192	1.505747	30	-21	121	126.4199
13	20	50	11	2.09	0.571	0.428	0.158	1.334112	2	-13	121	121.7127
14	20	74.5	10	10.16	1.326	0.468	0.249	2.833333	26.5	-14	121	124.6565
15	20	80	25.5	2.6	0.692	0.418	0.223	1.655502	32	1.5	121	125.1688
16	20	24	11	0.8	0.516	0.32	0.131	1.6125	-24	-13	121	124.0403
17	19	51.5	8.5	12.66	1.694	1.605	0.194	1.055451	3.5	-15.5	120.5	121.5432
18	19	30.5	4.75	0.11	0.449	0.141	0.025	3.184397	-17.5	-19.25	120.5	123.2763
19	19	18	17	4.17	0.786	0.429	0.25	1.832167	-30	-7	120.5	124.3754
20	19	12	18	2.3	0.716	0.41	0.152	1.746341	-36	-6	120.5	125.9057
23	18	77	7.25	0.95	0.641	0.279	0.11	2.297491	29	-16.75	120	124.5855
24	17	81.5	7	12.12	1.989	0.541	0.205	3.676524	33.5	-17	119.5	125.2657
25	17	59	13.5	0.32	0.351	0.16	0.115	2.19375	11	-10.5	119.5	120.4636
26	17	6.6	12	3.46	0.84	0.447	0.191	1.879194	-41.4	-12	119.5	127.0362
27	17	28.25	9	11.7	1.465	0.786	0.224	1.863867	-19.75	-15	119.5	122.0463
28	17	13.5	3.5	1.88	0.735	0.448	0.132	1.640625	-34.5	-20.5	119.5	126.0585
29	16	29	8	1.78	0.641	0.414	0.125	1.548309	-19	-16	119	121.5647
30	16	50	20.5	0.16	0.212	0.191	0.058	1.109947	2	-3.5	119	119.0682
31	16	37	36.5	2.35	0.73	0.329	0.235	2.218844	-11	12.5	119	120.1592
32	15	85.5	6	4.83	1.021	0.469	0.205	2.176972	37.5	-18	118.5	125.5886
33	14	48	24	2.33	0.875	0.335	0.16	2.611940	0	0	118	118
34	15	34	12	0.94	1.25	1.117	0.452	1.119068	-14	-12	118.5	119.9260
35	15	11	7.5	1.36	1.588	1.381	1.14	1.149891	-37	-16.5	118.5	125.2337
36	15	12	1.5	1.87	0.662	0.352	0.151	1.880681	-36	-22.5	118.5	125.8749
37	15	79	14.5	2.53	0.931	0.314	0.116	2.964968	31	-9.5	118.5	122.8556
38	15	48	24	0.52	0.337	0.2	0.12	1.685	0	0	118.5	118.5
39	14	12	26	2.5	0.766	0.413	0.171	1.854721	-36	2	118	123.3855
40	14	85.5	6	0.64	0.306	0.255	0.13	1.2	37.5	-18	118	125.1169
41	14	78	20.5	2.5	0.711	0.361	0.204	1.969529	30	-3.5	118	121.8041
42	14	11.5	8	5.58	1.536	1.402	0.182	1.095577	-36.5	-16	118	124.5481
43	14	9	24	6.36	1.474	1.212	1.194	1.216171	-39	0	118	124.2779
44	14	31.5	17.5	5.94	1.179	0.52	0.209	2.267307	-16.5	-6.5	118	119.3251
45	14	12.5	2	0.6	0.501	0.205	0.088	2.443902	-35.5	-22	118	125.1728
46	13	21.5	14.5	2.8	0.917	0.313	0.176	2.929712	-26.5	-9.5	117.5	120.8252
47	13	79.5	6	0.35	0.286	0.152	0.085	1.881578	31.5	-18	117.5	122.9735
48	13	78	21.5	1.08	1.476	0.354	0.089	4.169491	30	-2.5	117.5	121.2950
49	13	60.5	32	0.34	0.276	0.198	0.062	1.393939	12.5	8	117.5	118.4335
50	13	72	24	14.51	1.449	0.795	0.218	1.822641	24	0	117.5	119.9260
51	11	92	10.75	2.16	0.609	0.381	0.191	1.598425	44	-13.25	116.5	125.2350
52	11	92	11.5	1.6	0.595	0.289	0.163	2.058823	44	-12.5	116.5	125.1579
53	11	48	24	0.58	0.506	0.288	0.084	1.756944	0	0	116.5	116.5
54	10	73	1.75	0.48	0.511	0.179	0.068	2.854748	25	-22.25	116	120.7313

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENETRATION X' (in)	COORDINATE Y' (in)	Z' (in)	DEPTH R' (in)	Xo	Yo	PRESENTED AREA (IN)² MAX.	MIN.	AVG.
1	-0.00595	-0.18253	-0.08928	-2.73809	15	15.24811	-0.66071	-20.2619	0.237513	0.042789	0.140151
2	0.370517	-0.05179	5.372509	-0.75099	14.5	15.48153	41.12749	-5.74900	0.026802	0.018423	0.022613
3	0.032128	-0.10040	0.433734	-1.35542	13.5	13.57480	3.566265	-11.1445	0.260265	0.063486	0.161876
4	-0.27309	-0.17068	-3.68674	-2.30421	13.5	14.18278	-30.3132	-18.9457	0.078231	0.020656	0.049443
5	0.008032	0.040160	0.108433	0.542168	13.5	13.51131	0.891566	4.457831	0.215904	0.049765	0.132835
6	0.379032	-0.05241	4.927419	-0.68145	13	13.91918	42.07258	-5.81854	0.114271	0.030875	0.072573
7	0.008064	-0.04838	0.104838	-0.62903	13	13.01563	0.895161	-5.37096	0.367955	0.073591	0.220773
8	0.026315	-0.10931	0.328947	-1.36639	12.5	12.57876	2.921052	-12.1336	0.047411	0.013031	0.030221
9	0.098360	-0.09426	1.081967	-1.03688	11	11.10161	10.91803	-10.4631	0.241400	0.044363	0.142882
10	-0.19753	-0.16460	-2.07407	-1.72839	10.5	10.84154	-21.9259	-18.2716	0.136442	0.038666	0.087554
11	0.115226	0.057613	1.209876	0.604938	10.5	10.58677	12.79012	6.395061	0.132713	0.038677	0.085695
12	0.247933	-0.17355	2.479338	-1.73553	10	10.44792	27.52066	-19.2644	0.131666	0.038595	0.085131
13	0.016528	-0.10743	0.165289	-1.07438	10	10.05890	1.834710	-11.9256	0.102892	0.028471	0.065681
14	0.219008	-0.11570	2.190082	-1.15702	10	10.30219	24.30991	-12.8429	0.317386	0.059599	0.188493
15	0.264462	0.012396	2.644628	0.123966	10	10.34453	29.35537	1.376033	0.090690	0.029225	0.059958
16	-0.19834	-0.10743	-1.98347	-1.07438	10	10.25126	-22.0165	-11.9256	0.047502	0.012059	0.029780
17	0.029045	-0.12863	0.275933	-1.22199	9.5	9.582244	3.224066	-14.2780	0.507605	0.058131	0.282868
18	-0.14522	-0.15975	-1.37966	-1.51763	9.5	9.718883	-16.1203	-17.7323	0.034225	0.001905	0.018065
19	-0.24896	-0.05809	-2.36514	-0.55186	9.5	9.805532	-27.6348	-6.44813	0.129744	0.041267	0.085506
20	-0.29875	-0.04979	-2.83817	-0.47302	9.5	9.926176	-33.1618	-5.52697	0.117700	0.024986	0.071343
23	0.241666	-0.13958	2.175	-1.25625	9	9.343917	26.825	-15.4937	0.067177	0.011528	0.039352
24	0.280334	-0.14225	2.382845	-1.20920	8.5	8.910113	31.11715	-15.7907	0.459878	0.047398	0.253638
25	0.092050	-0.08786	0.782426	-0.74686	8.5	8.568546	10.21757	-9.75313	0.021644	0.007091	0.014367
26	-0.34644	-0.10041	-2.94476	-0.85355	8.5	9.036051	-38.4552	-11.1464	0.140908	0.032039	0.086474
27	-0.16527	-0.12552	-1.40481	-1.06694	8.5	8.681121	-18.3451	-13.9330	0.406286	0.062121	0.234203
28	-0.28870	-0.17154	-2.45397	-1.45815	8.5	8.966505	-32.0460	-19.0418	0.110784	0.019895	0.065340
29	-0.15966	-0.13445	-1.27731	-1.07563	8	8.172423	-17.7226	-14.9243	0.110765	0.021600	0.066182
30	0.016806	-0.02941	0.134453	-0.23529	8	8.004588	1.865546	-3.26470	0.021457	0.005870	0.013664
31	-0.09243	0.105042	-0.73949	0.840336	8	8.077934	-10.2605	11.65966	0.077784	0.025040	0.051412
32	0.316455	-0.15189	2.373417	-1.13924	7.5	7.948646	35.12658	-16.8607	0.183268	0.036797	0.110032
33	0	0	0	0	7	7	0	0	0.113273	0.020712	0.066993
34	-0.11814	-0.10126	-0.88607	-0.75949	7.5	7.590254	-13.1139	-11.2405	0.016176	0.005849	0.011012
35	-0.31223	-0.13924	-2.34177	-1.04430	7.5	7.926188	-34.6582	-15.4556	0.009279	0.006661	0.007970
36	-0.30379	-0.18987	-2.27848	-1.42405	7.5	7.966768	-33.7215	-21.0759	0.096329	0.021972	0.059150
37	0.261603	-0.08016	1.962025	-0.60126	7.5	7.775671	29.03797	-8.89873	0.169651	0.021138	0.095394
38	0	0	0	0	7.5	7.5	0	0	0.033706	0.012002	0.022854
39	-0.30508	0.016949	-2.13559	0.118644	7	7.319483	-33.8644	1.881355	0.113720	0.025386	0.069553
40	0.317796	-0.15254	2.224576	-1.06779	7	7.422191	35.27542	-16.9322	0.038294	0.016268	0.027281
41	0.254237	-0.02966	1.779661	-0.20762	7	7.225669	28.22033	-3.29237	0.095324	0.027350	0.061337
42	-0.30932	-0.13559	-2.16525	-0.94915	7	7.388451	-34.3347	-15.0508	0.238482	0.028257	0.133370
43	-0.33050	0	-2.31355	0	7	7.372418	-36.6864	0	0.041433	0.033562	0.037497
44	-0.13983	-0.05508	-0.97881	-0.38559	7	7.078612	-15.5211	-6.11440	0.221072	0.039189	0.130130
45	-0.30084	-0.18644	-2.10593	-1.30508	7	7.425509	-33.3940	-20.6949	0.053035	0.009315	0.031175
46	-0.22553	-0.08085	-1.46595	-0.52553	6.5	6.683952	-25.0340	-8.97446	0.123748	0.023751	0.073749
47	0.268085	-0.15319	1.742553	-0.99574	6.5	6.802793	29.75744	-17.0042	0.032028	0.009519	0.020774
48	0.255319	-0.02127	1.659574	-0.13829	6.5	6.709941	28.34042	-2.36170	0.094390	0.005691	0.050040
49	0.106382	0.068085	0.691489	0.442553	6.5	6.551641	11.80851	7.557446	0.042656	0.009582	0.026119
50	0.204255	0	1.327659	0	6.5	6.634205	22.67234	0	0.517732	0.077892	0.297812
51	0.377682	-0.11373	2.077253	-0.62553	5.5	5.912383	41.92274	-12.6244	0.087965	0.027588	0.057777
52	0.377682	-0.10729	2.077253	-0.59012	5.5	5.908742	41.92274	-11.9098	0.076353	0.020916	0.048634
53	0	0	0	0	5.5	5.5	0	0	0.053708	0.008916	0.031312
54	0.215517	-0.19181	1.077586	-0.95905	5	5.203938	23.92241	-21.2909	0.054906	0.007306	0.031106

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vol. Screen X1	Locations Y1	(1-8)	VEL. (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
1	40.74166	4084.351	1129.422	2606.887	1.019129	2	-99	0	0	1.02E+00	0.00E+00	0.00E+00
2	185.2904	1014.500	765.8729	890.1869	0.255367	99	-1	0	0	0.00E+00	0.00E+00	0.00E+00
3	43.61362	3419.246	1186.807	2303.027	1.113204	3	-1	7	2303.027	0.00E+00	0.00E+00	1.11E+00
4	35.39366	4083.207	1504.005	2793.606	0.334714	1	-99	0	0	3.35E-01	0.00E+00	0.00E+00
5	54.95537	2888.341	960.8402	1924.591	0.961905	3	1	3	1924.591	0.00E+00	0.00E+00	0.00E+00
6	39.27056	3710.661	1390.622	2550.641	0.497697	99	-1	0	0	0.00E+00	0.00E+00	0.00E+00
7	49.28133	3105.597	928.7903	2017.194	1.502614	3	-1	7	2017.194	0.00E+00	0.00E+00	0.00E+00
8	21.17676	5450.402	2069.059	3759.731	0.164743	3	-99	0	0	0.00E+00	0.00E+00	1.65E-01
9	31.49444	3895.880	1093.512	2494.696	0.768601	3	-1	7	2494.696	0.00E+00	0.00E+00	7.69E-01
10	48.88398	2590.408	1006.139	1798.273	0.526951	1	-99	0	0	5.27E-01	0.00E+00	0.00E+00
11	42.00928	2837.611	1125.539	1981.575	0.488409	3	1	3	1981.575	0.00E+00	0.00E+00	0.00E+00
12	38.17640	3015.705	1201.389	2108.547	0.469178	4	-99	0	0	4.69E-01	0.00E+00	0.00E+00
13	31.82009	3392.441	1294.279	2343.360	0.335317	3	-1	7	2343.360	0.00E+00	0.00E+00	3.35E-01
14	53.90116	2455.499	700.4574	1577.978	1.097655	4	-99	0	0	0.00E+00	0.00E+00	1.10E+00
15	43.36363	2675.449	1144.315	1909.882	0.339978	4	1	4	1909.882	0.00E+00	0.00E+00	0.00E+00
16	26.86288	3960.242	1416.406	2688.324	0.147245	1	-1	5	2688.324	0.00E+00	0.00E+00	1.47E-01
17	44.75576	2804.408	552.0869	1678.247	1.454657	3	-99	0	0	0.00E+00	1.45E+00	0.00E+00
18	6.088970	13177.99	1510.496	7344.246	0.055310	2	-99	0	0	0.00E+00	5.53E-02	0.00E+00
19	48.76841	2359.068	999.1452	1679.106	0.479386	1	-1	5	1679.106	0.00E+00	0.00E+00	0.00E+00
20	32.23834	3457.768	1081.418	2269.593	0.357393	1	-1	5	2269.593	0.00E+00	0.00E+00	0.00E+00
23	24.14052	4211.573	1122.911	2667.242	0.173483	4	-99	0	0	0.00E+00	1.73E-01	0.00E+00
24	47.78459	2547.939	463.4773	1505.708	1.249437	4	-99	0	0	0.00E+00	1.25E+00	0.00E+00
25	22.27177	3817.237	1653.073	2735.155	0.059924	3	-1	7	2735.155	0.00E+00	0.00E+00	5.99E-02
26	40.01196	2715.195	894.0600	1804.627	0.427498	-99	-1	0	0	0.00E+00	0.00E+00	4.27E-01
27	49.95648	2337.964	571.6705	1454.817	1.165374	1	-99	0	0	0.00E+00	1.17E+00	0.00E+00
28	28.77252	3561.468	982.5259	2271.997	0.292439	1	-99	0	0	2.92E-01	0.00E+00	0.00E+00
29	26.89522	3460.770	1015.574	2238.172	0.272762	2	-99	0	0	0.00E+00	2.73E-01	0.00E+00
30	11.70943	6060.736	2292.685	4176.711	0.045753	3	-1	7	4176.711	0.00E+00	0.00E+00	0.00E+00
31	45.70874	2136.812	913.2195	1525.016	0.245365	2	1	2	1525.016	0.00E+00	0.00E+00	0.00E+00
32	43.89600	2338.819	701.5242	1520.171	0.502702	4	-99	0	0	0.00E+00	5.03E-01	0.00E+00
33	34.77951	2560.505	715.9944	1638.249	0.261340	3	1	3	1638.249	0.00E+00	0.00E+00	0.00E+00
34	85.35417	1248.620	582.2397	915.4302	0.058914	2	-1	6	915.4302	0.00E+00	0.00E+00	5.89E-02
35	170.6266	644.4835	502.6348	573.5591	0.053405	1	-99	0	0	0.00E+00	5.34E-02	0.00E+00
36	31.61405	2946.599	972.5462	1959.572	0.250884	1	-99	0	0	2.51E-01	0.00E+00	0.00E+00
37	26.52142	3526.160	739.4916	2132.826	0.369442	4	-1	8	2132.826	0.00E+00	0.00E+00	3.69E-01
38	22.75258	3345.816	1542.288	2444.052	0.087013	3	1	3	2444.052	0.00E+00	0.00E+00	0.00E+00
39	35.94356	2518.867	818.0519	1668.459	0.285579	1	1	1	1668.459	0.00E+00	0.00E+00	0.00E+00
40	23.45925	3126.322	1645.129	2385.726	0.104537	4	-99	0	0	0.00E+00	1.05E-01	0.00E+00
41	40.75815	2185.385	856.7389	1521.062	0.260350	4	-1	8	1521.062	0.00E+00	0.00E+00	0.00E+00
42	41.83842	2420.770	488.8929	1454.831	0.555799	1	-99	0	0	0.00E+00	5.56E-01	0.00E+00
43	165.6101	589.5849	503.4154	546.5001	0.237967	-99	1	0	0	0.00E+00	0.00E+00	0.00E+00
44	45.64639	2113.214	577.3217	1345.268	0.547099	2	-1	6	1345.268	0.00E+00	0.00E+00	0.00E+00
45	19.24602	4190.586	1136.994	2663.790	0.109426	1	-99	0	0	1.09E-01	0.00E+00	0.00E+00
46	37.96624	2302.674	667.7134	1485.194	0.284716	1	-1	5	1485.194	0.00E+00	0.00E+00	2.85E-01
47	16.84754	4027.572	1621.186	2824.379	0.067680	4	-99	0	0	0.00E+00	6.77E-02	0.00E+00
48	21.58230	3851.134	468.6152	2159.874	0.159706	4	-1	8	2159.874	0.00E+00	0.00E+00	0.00E+00
49	13.01727	4960.905	1618.724	3289.815	0.076581	3	1	3	3289.815	0.00E+00	0.00E+00	0.00E+00
50	48.72200	1950.255	471.1210	1210.688	1.202737	4	1	4	1210.688	0.00E+00	0.00E+00	0.00E+00
51	37.38492	1975.327	827.8489	1401.588	0.207274	99	-99	0	0	0.00E+00	0.00E+00	2.07E-01
52	32.89813	2223.682	842.0263	1532.854	0.167915	99	-1	0	0	0.00E+00	0.00E+00	1.68E-01
53	18.52309	3464.612	901.0549	2182.833	0.086680	3	1	3	2182.833	0.00E+00	0.00E+00	0.00E+00
54	15.43075	3894.570	858.0756	2376.322	0.078094	4	-99	0	0	7.91E-02	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	2.55E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	9.62E-01	0.00E+00	0.00E+00	0.00E+00
6	4.98E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	4.88E-01	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	3.40E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	4.79E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	3.57E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	0.00E+00	4.58E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	0.00E+00	0.00E+00	0.00E+00	2.45E-01	0.00E+00	0.00E+00
32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	0.00E+00	2.61E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
38	0.00E+00	8.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	0.00E+00	2.86E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41	0.00E+00	2.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
43	0.00E+00	2.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
44	5.47E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	0.00E+00	1.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	0.00E+00	0.00E+00	7.[illegible]6E-02	0.00E+00	0.00E+00	0.00E+00
50	0.00E+00	1.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
52	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53	0.00E+00	8.67E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
55	10	76	21	1.6	0.638	0.384	0.159	1.661456	28	-3	116	119.3691
56	10	55	27	1.84	0.644	0.384	0.138	1.677063	7	3	116	116.2497
57	10	18.25	6	0.57	0.466	0.203	0.106	2.295566	-29.75	-18	116	121.0993
58	10	19.5	29	2.18	0.736	0.428	0.142	1.719626	-28.5	5	116	119.5543
59	10	43	19	1.37	0.505	0.437	0.141	1.155606	-5	-5	116	116.2153
60	10	20	15	1.6	0.579	0.342	0.125	1.692982	-28	-9	116	119.6703
61	9	71.5	1.5	0.99	0.444	0.259	0.104	1.714285	23.5	-22.5	115.5	119.9947
62	9	78.5	17.5	2.11	0.756	0.403	0.163	1.875930	30.5	-6.5	115.5	119.6359
63	9	75.5	21	0.46	0.466	0.213	0.133	2.187793	27.5	-3	115.5	118.7665
64	9	77.5	34	0.79	0.443	0.272	0.13	1.628676	29.5	10	115.5	119.6265
65	9	53	45	0.44	0.441	0.198	0.11	2.227272	5	21	115.5	117.5
66	9	35	8.5	1.96	0.946	0.241	0.121	3.925311	-13	-15.5	115.5	117.2582
67	9	30.5	17.5	0.53	0.51	0.225	0.08	2.266666	-17.5	-6.5	115.5	116.9989
68	9	82	24	1.77	0.654	0.368	0.149	1.777173	34	0	115.5	120.4003
69	8	72	24	1.07	0.579	0.32	0.103	1.809375	24	0	115	117.4776
70	8	70	24	0.32	0.394	0.224	0.126	1.758928	22	0	115	117.0854
71	8	30	24	1.4	0.605	0.458	0.112	1.320960	-18	0	115	116.4001
72	8	12	11	3.73	1.079	0.473	0.142	2.281183	-36	-13	115	121.2023
73	8	38.5	6	2.97	1.199	0.318	0.11	3.770440	-9.5	-18	115	116.7871
74	8	46.5	6.5	1.41	0.751	0.31	0.106	2.422580	-1.5	-17.5	115	116.3335
75	8	50	6.5	2.4	0.771	0.39	0.142	1.976923	2	-17.5	115	116.3410
76	8	70.5	15	0.48	0.561	0.225	0.074	2.493333	22.5	-9	115	117.5255
77	8	73	5.5	0.29	0.323	0.21	0.082	1.538095	25	-18.5	115	119.1312
78	8	77.5	11	0.13	0.283	0.211	0.062	1.341232	29.5	-13	115	119.4330
79	8	81	13.25	0.1	0.231	0.122	0.071	1.893442	33	-10.75	115	120.1231
80	8	81.5	35.5	0.41	0.355	0.245	0.083	1.448979	33.5	11.5	115	120.3307
81	8	29	8.5	0.1	0.324	0.205	0.03	1.580487	-19	-15.5	115	117.5850
82	7	29	4	1.98	0.581	0.377	0.125	1.541114	-19	-20	114.5	117.7762
83	7	48	11	1.96	1.582	1.511	0.151	1.046988	0	-13	114.5	115.2356
84	7	78	4	0.5	0.303	0.312	0.075	0.971153	30	-20	114.5	120.0427
85	7	63.5	4	0.24	0.311	0.171	0.073	1.818713	15.5	-20	114.5	117.2525
86	7	60	4	0.07	0.256	0.156	0.034	1.641025	12	-20	114.5	116.8514
87	7	18	17	0.8	0.619	0.215	0.115	2.874418	-30	-7	114.5	118.5717
88	7	16.5	12	0.48	0.381	0.3	0.08	1.27	-31.5	-12	114.5	119.3587
89	7	23	16	0.61	0.473	0.241	0.125	1.962655	-25	-8	114.5	117.4702
90	7	28	19.5	0.14	0.234	0.194	0.065	1.206185	-20	-4.5	114.5	116.3206
91	7	22	26	0.5	0.684	0.3	0.082	2.28	-26	2	114.5	117.4318
92	7	28.5	36	0.72	0.545	0.276	0.1	1.974637	-19.5	12	114.5	116.7668
93	7	37	16	1.11	1.735	0.337	0.092	5.148367	-11	-8	114.5	115.3050
94	7	54.5	35	0.5	0.576	0.194	0.117	2.969072	6.5	11	114.5	115.2106
95	7	24	17	0.5	0.453	0.244	0.086	1.856557	-24	-7	114.5	117.1974
96	6	89	24	0.36	0.511	0.174	0.091	2.936781	41	0	114	121.1486
97	6	70	24	1.41	0.673	0.309	0.145	2.177993	22	0	114	116.1034
98	6	49	24	4.28	1.053	0.365	0.163	2.884931	1	0	114	114.0043
99	6	45	24	1.54	0.706	0.579	0.118	1.219343	-3	0	114	114.0394
100	6	4	11.5	0.95	0.455	0.269	0.15	1.691449	-44	-12.5	114	122.8342
101	6	18	12.5	0.46	0.448	0.2	0.1	2.24	-30	-11.5	114	118.4409
102	6	16.5	14	0.33	0.425	0.12	0.104	3.541666	-31.5	-10	114	118.6939
103	6	23.5	17	0.67	0.5	0.304	0.131	1.644736	-24.5	-7	114	116.8128
104	6	15.5	34.5	0.16	0.229	0.145	0.121	1.579310	-32.5	10.5	114	119.0063
105	6	22	39.5	0.46	0.502	0.249	0.081	2.016064	-26	15.5	114	117.9502
106	6	36	13	3.69	1.307	0.423	0.129	3.089834	-12	-11	114	115.1564

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENETRATION X'(in)	PENETRATION Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED AREA (IN)² MAX.	MIN.	AVG.
55	0.241379	-0.02586	1.206896	-0.12931	5	5.145223	26.79310	-2.87068	0.078273	0.019507	0.048890
56	0.060344	0.025862	0.301724	0.129310	5	5.010764	6.698275	2.870689	0.103712	0.022224	0.062968
57	-0.25646	-0.15517	-1.28232	-0.77586	5	5.219801	-28.4676	-17.2241	0.041827	0.009514	0.025671
58	-0.24568	0.043103	-1.22844	0.215517	5	5.153206	-27.2715	4.784482	0.119415	0.023039	0.071227
59	-0.04310	-0.04310	-0.21551	-0.21551	5	5.009280	-4.78448	-4.78448	0.075578	0.021101	0.048340
60	-0.24137	-0.07758	-1.20683	-0.38793	5	5.158206	-26.7931	-8.61206	0.099564	0.021494	0.060523
61	0.203463	-0.19480	0.915584	-0.87662	4.5	4.675121	22.58441	-21.6233	0.074045	0.017343	0.045694
62	0.264069	-0.05627	1.188311	-0.25324	4.5	4.661139	29.31168	-6.24675	0.100690	0.021709	0.061200
63	0.238095	-0.02597	1.071428	-0.11688	4.5	4.627269	26.42857	-2.88311	0.026902	0.007678	0.017290
64	0.255411	0.086580	1.149350	0.389610	4.5	4.660772	28.35064	9.610389	0.047269	0.013871	0.030570
65	0.043290	0.181818	0.194805	0.818181	4.5	4.577922	4.805194	20.18181	0.031113	0.007760	0.019437
66	-0.11255	-0.13419	-0.50649	-0.60389	4.5	4.568503	-12.4935	-14.8961	0.125998	0.016116	0.071057
67	-0.15151	-0.05627	-0.68181	-0.25324	4.5	4.558399	-16.8181	-6.24675	0.051532	0.008083	0.029807
68	0.294372	0	1.324675	0	4.5	4.690923	32.67532	0	0.092401	0.021051	0.056726
69	0.208695	0	0.834782	0	4	4.096179	23.16521	0	0.080805	0.014374	0.047590
70	0.191304	0	0.765217	0	4	4.072537	21.23478	0	0.019754	0.006317	0.013036
71	-0.15652	0	-0.62508	0	4	4.048701	-17.3739	0	0.097230	0.017999	0.057615
72	-0.31304	-0.11304	-1.25217	-0.45217	4	4.215732	-34.7478	-12.5478	0.204321	0.026869	0.115605
73	-0.08260	-0.15652	-0.33043	-0.62608	4	4.062163	-9.16956	-17.3739	0.210018	0.019267	0.114643
74	-0.01304	-0.15217	-0.05217	-0.60869	4	4.046385	-1.44792	-16.8913	0.103468	0.014604	0.059036
75	0.017391	-0.15217	0.069565	-0.60869	4	4.046646	1.930434	-16.8913	0.131467	0.024213	0.077840
76	0.195652	-0.07826	0.782608	-0.31304	4	4.087844	21.71739	-8.68695	0.050454	0.006655	0.028555
77	0.217391	-0.16086	0.869565	-0.64347	4	4.143694	24.13043	-17.8565	0.027509	0.006983	0.017246
78	0.256521	-0.11304	1.026086	-0.45217	4	4.154192	28.47391	-12.5478	0.016303	0.003573	0.009941
79	0.286956	-0.09347	1.147826	-0.37391	4	4.178195	31.85217	-10.3760	0.010955	0.003367	0.007161
80	0.291304	0.1	1.165217	0.4	4	4.185418	32.33478	11.1	0.036423	0.008983	0.023703
81	-0.16521	-0.13478	-0.66086	-0.53913	4	4.089915	-18.3391	-14.9608	0.025928	0.002400	0.014164
82	-0.16593	-0.17467	-0.58078	-0.61135	3.5	3.600148	-18.4192	-19.3886	0.123210	0.026508	0.074859
83	0	-0.11353	0	-0.39737	3.5	3.522486	0	-12.6026	0.100965	0.009637	0.055301
84	0.262008	-0.17467	0.917030	-0.61135	3.5	3.669427	29.09296	-19.3886	0.051856	0.012835	0.032346
85	0.135371	-0.17467	0.473799	-0.61135	3.5	3.584444	15.02620	-19.3886	0.025573	0.006002	0.015787
86	0.104803	-0.17467	0.366812	-0.61135	3.5	3.571876	11.63318	-19.3886	0.016014	0.002126	0.009070
87	-0.26200	-0.06113	-0.91703	-0.21397	3.5	3.624462	-29.0829	-6.78602	0.054111	0.010069	0.032090
88	-0.27510	-0.10480	-0.96288	-0.36681	3.5	3.648519	-30.5371	-11.6331	0.046670	0.009799	0.028235
89	-0.21834	-0.06986	-0.76419	-0.24454	3.5	3.590792	-24.2358	-7.75545	0.037958	0.010031	0.023995
90	-0.17467	-0.03930	-0.61135	-0.13755	3.5	3.555653	-19.3886	-4.36244	0.016753	0.004653	0.010703
91	-0.22707	0.017467	-0.79475	0.061135	3.5	3.589621	-25.2052	1.938964	0.056915	0.006823	0.031869
92	-0.17030	0.104803	-0.59606	0.366812	3.5	3.569292	-18.9039	11.63319	0.056004	0.010276	0.033140
93	-0.09606	-0.06986	-0.33624	-0.24454	3.5	3.524607	-10.6637	-7.75545	0.093848	0.004976	0.049412
94	0.056768	0.096069	0.196689	0.336244	3.5	3.521723	6.301310	10.66375	0.033241	0.006752	0.019996
95	-0.20960	-0.06113	-0.73362	-0.21397	3.5	3.582455	-23.2663	-6.78602	0.045223	0.008585	0.026904
96	0.359649	0	1.078947	0	3	3.198122	39.92105	0	0.030771	0.005479	0.018125
97	0.192982	0	0.578947	0	3	3.055352	21.42105	0	0.075638	0.016296	0.045967
98	0.008771	0	0.026315	0	3	3.000115	0.973684	0	0.204244	0.031616	0.117930
99	-0.02631	0	-0.07894	0	3	3.001038	-2.92105	0	0.101515	0.016967	0.059241
100	-0.38596	-0.10964	-1.15789	-0.32894	3	3.232479	-42.8421	-12.1710	0.049263	0.016240	0.032752
101	-0.26315	-0.10087	-0.78947	-0.30263	3	3.116866	-29.2105	-11.1973	0.035780	0.007986	0.021883
102	-0.27631	-0.08771	-0.82894	-0.26315	3	3.123524	-30.6710	-9.73684	0.024681	0.006039	0.015360
103	-0.21491	-0.06140	-0.64473	-0.18421	3	3.074023	-23.8552	-6.81578	0.039783	0.010423	0.025103
104	-0.28508	0.092105	-0.85526	0.276315	3	3.131744	-31.6447	10.22368	0.010285	0.005434	0.007860
105	-0.22807	0.135964	-0.68421	0.407894	3	3.103952	-25.3157	15.09210	0.044174	0.007127	0.025650
106	-0.10526	-0.09649	-0.31578	-0.28947	3	3.030431	-11.6842	-10.7105	0.222500	0.021960	0.122230

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Locations (1-8) X1	Y1		VEL. (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
55	32.72618	2042.196	720.3271	1381.261	0.151309	4	-1	8	1381.261	0.00E+00	0.00E+00	0.00E+00
56	29.22093	2226.439	701.2222	1463.830	0.184407	3	1	3	1463.830	0.00E+00	0.00E+00	0.00E+00
57	22.20402	2798.035	921.6015	1859.818	0.072579	1	-99	0	0	0.00E+00	7.26E-02	0.00E+00
58	30.60606	2225.532	647.8760	1436.704	0.214434	1	1	1	1436.704	0.00E+00	0.00E+00	0.00E+00
59	26.34091	2190.328	841.3082	1515.818	0.142180	2	-1	6	1515.818	0.00E+00	0.00E+00	0.00E+00
60	26.43332	2450.663	776.1706	1613.416	0.176741	1	-1	5	1613.416	0.00E+00	0.00E+00	1.77E-01
61	21.66564	2613.134	879.8316	1746.483	0.118377	4	-99	0	0	1.18E-01	0.00E+00	0.00E+00
62	34.47702	1861.317	588.9383	1225.127	0.176984	4	-1	8	1225.127	0.00E+00	0.00E+00	0.00E+00
63	26.60397	2156.239	841.9693	1499.104	0.047212	4	-1	8	1499.104	0.00E+00	0.00E+00	0.00E+00
64	25.84213	2205.352	879.2913	1542.322	0.083420	4	1	4	1542.322	0.00E+00	0.00E+00	0.00E+00
65	22.63682	2466.317	870.4914	1668.404	0.050260	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
66	27.58340	2292.628	490.3478	1391.487	0.186726	2	-99	0	0	0.00E+00	1.87E-01	0.00E+00
67	17.78050	3121.648	778.0792	1949.863	0.370754	2	-1	6	1949.863	0.00E+00	0.00E+00	0.00E+00
68	31.20213	2000.535	659.7092	1330.122	0.161189	4	1	4	1330.122	0.00E+00	0.00E+00	0.00E+00
69	22.48367	2379.316	651.7353	1515.526	0.111024	4	1	4	1515.526	0.00E+00	0.00E+00	0.00E+00
70	24.54704	2040.389	867.6983	1454.043	0.031856	4	1	4	1454.043	0.00E+00	0.00E+00	0.00E+00
71	24.29909	2219.041	626.2711	1422.656	0.136363	2	1	2	1422.656	0.00E+00	0.00E+00	0.00E+00
72	32.26487	1914.391	418.2932	1166.342	0.297855	1	-99	0	0	0.00E+00	0.00E+00	2.98E-01
73	25.90646	2254.839	375.8770	1315 358	0.267467	2	-99	0	0	0.00E+00	2.67E-01	0.00E+00
74	23.88365	2311.602	532.3075	1421.954	0.137270	2	-99	0	0	0.00E+00	1.37E-01	0.00E+00
75	30.83243	1856.513	521.9426	1169.226	0.195410	3	-99	0	0	0.00E+00	1.95E-01	0.00E+00
76	16.80957	3049.924	667.5607	1858.742	0.061084	4	-1	8	1858.742	0.00E+00	0.00E+00	6.11E-02
77	16.81501	2852.808	1020.307	1936.557	0.938450	4	-99	0	0	0.00E+00	3.85E-02	0.00E+00
78	13.07660	3525.034	1128.800	2326.917	0.020710	4	-99	0	0	0.00E+00	0.00E+00	2.07E-02
79	13.96365	3198.084	1320.154	2259.119	0.015467	4	-1	8	2259.119	0.00E+00	0.00E+00	1.55E-02
80	17.29689	2848.313	957.6902	1903.001	0.053418	4	1	4	1903.001	0.00E+00	0.00E+00	0.00E+00
81	7.059905	6005.331	1008.019	3506.675	0.024008	1	-99	0	0	0.00E+00	2.40E-02	0.00E+00
82	26.44949	1871.327	591.1535	1231.240	0.166908	1	-99	0	0	1.67E-01	0.00E+00	0.00E+00
83	35.44220	1597.704	274.3621	936.0332	0.125608	3	-99	0	0	0.00E+00	0.00E+00	1.26E-01
84	15.45780	2784.485	977.1447	1880.815	0.064385	4	-99	0	0	6.44E-02	0.00E+00	0.00E+00
85	15.20155	2792.005	941.5397	1866.772	0.030674	3	-99	0	0	3.07E-02	0.00E+00	0.00E+00
86	7.717146	4939.185	1086.637	3012.911	0.014439	3	-99	0	0	1.44E-02	0.00E+00	0.00E+00
87	24.92976	2002.172	567.2617	1284.717	0.0703[illegible]	1	-1	5	1284.717	0.00E+00	0.00E+00	0.00E+00
88	17.00003	2641.570	819.3810	1730.475	0.056969	1	-1	5	1730.475	0.00E+00	0.00E+00	5.69E-02
89	25.42177	1867.679	688.3970	1278.038	0.053375	1	-1	5	1278.038	0.00E+00	0.00E+00	0.00E+00
90	13.07958	3027.587	1158.430	2093.008	0.020061	1	-1	5	2093.008	0.00E+00	0.00E+00	0.00E+00
91	18.82682	2561.640	521.8990	1541.769	0.063334	1	1	1	1541.769	0.00E+00	0.00E+00	0.00E+00
92	21.72564	2198.005	616.2137	1407.109	0.069363	1	1	1	1407.109	0.00E+00	0.00E+00	0.00E+00
93	22.46387	2317.844	256.1242	1286.984	0.097806	2	-1	6	1286.984	0.00E+00	0.00E+00	0.00E+00
94	25.00408	1934.279	585.2504	1259.764	0.043125	3	1	3	1259.764	0.00E+00	0.00E+00	0.00E+00
95	18.56419	2468.049	709.8295	1588.939	0.054393	1	-1	5	1588.939	0.00E+00	0.00E+00	0.00E+00
96	19.86102	2167.516	594.1932	1380.854	0.034034	99	1	0	0	0.00E+00	0.00E+00	0.00E+00
97	30.67366	1480.342	468.1411	974.2417	0.094049	4	1	4	974.2417	0.00E+00	0.00E+00	0.00E+00
98	36.29261	1337.534	330.0838	833.8090	0.244332	3	1	3	833.8090	0.00E+00	0.00E+00	0.00E+00
99	25.99533	1704.646	445.5970	1075.121	0.113357	2	1	2	1075.121	0.00E+00	0.00E+00	0.00E+00
100	29.00568	1505.482	654.9912	1080.236	0.070260	-99	-99	0	0	0.00E+00	0.00E+00	7.03E-02
101	21.02002	1985.549	644.7958	1315.172	0.041420	1	-1	5	1315.172	0.00E+00	0.00E+00	4.14E-02
102	21.48337	1931.082	671.8692	1301.475	0.029404	1	-1	5	1301.475	0.00E+00	0.00E+00	2.94E-02
103	26.68995	1604.793	587.6855	1096.239	0.050286	1	-1	5	1096.239	0.00E+00	0.00E+00	0.00E+00
104	20.35582	1727.201	1070.422	1398.811	0.015323	1	1	1	1398.811	0.00E+00	0.00E+00	0.00E+00
105	17.93312	2318.273	590.2019	1454.237	0.045799	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
106	30.18886	1506.120	282.8224	944.4717	0.238606	2	-1	6	944.4717	0.00E+00	0.00E+00	2.39E-01

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
55	0.00E+00	1.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	0.00E+00	1.84E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
57	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
58	0.00E+00	0.00E+00	2.14E-01	0.00E+00	0.00E+00	0.00E+00
59	1.42E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
62	1.77E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
63	0.00E+00	4.72E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	0.00E+00	0.00E+00	0.00E+00	8.34E-02	0.00E+00	0.00E+00
65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.03E-02
66	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	7.08E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
68	0.00E+00	1.61E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69	0.00E+00	1.11E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	0.00E+00	3.19E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71	0.00E+00	1.36E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
72	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
73	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
74	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
76	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
77	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
78	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
79	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	0.00E+00	0.00E+00	0.00E+00	5.34E-02	0.00E+00	0.00E+00
81	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
82	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
83	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
86	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
87	7.04E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
89	5.34E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90	2.01E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
91	0.00E+00	6.33E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
92	0.00E+00	0.00E+00	0.00E+00	6.94E-02	0.00E+00	0.00E+00
93	9.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
94	0.00E+00	0.00E+00	0.00E+00	4.31E-02	0.00E+00	0.00E+00
95	5.44E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
96	0.00E+00	3.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
97	0.00E+00	9.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
98	0.00E+00	2.44E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
99	0.00E+00	1.13E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
102	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
103	5.03E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
104	0.00E+00	0.00E+00	0.00E+00	1.53E-02	0.00E+00	0.00E+00
105	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.58E-02	0.00E+00
106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES. X (in)	POSITION COORDINATES. Y (in)	POSITION COORDINATES. Z (in)	PATH R (in)
107	6	40	18.5	0.59	0.49	0.279	0.11	1.756272	-8	-5.5	114	114.4126
108	6	50.5	17	0.37	0.356	0.204	0.02	1.745098	2.5	-7	114	114.2420
109	6	51.25	41.25	0.29	0.299	0.214	0.089	1.397196	3.25	17.25	114	115.3435
110	6	36.5	20.5	0.69	0.582	0.3	0.086	1.94	-11.5	-3.5	114	114.6320
111	6	67	16	0.11	0.308	0.178	0.064	1.730337	19	-8	114	115.8490
112	6	67	20	0.73	0.615	0.243	0.09	2.530864	19	-4	114	115.6416
113	6	66.5	7.5	0.41	0.426	0.236	0.072	1.805084	18.5	-16.5	114	116.6640
114	6	74	9	0.36	0.474	0.334	0.055	1.419161	26	-15	114	117.8855
115	6	77	9	0.6	0.548	0.284	0.085	1.929577	29	-15	114	118.5833
116	6	81	27.5	0.1	0.202	0.125	0.08	1.616	33	3.5	114	118.7318
117	6	83	15	0.11	0.202	0.111	0.078	1.819819	35	-9	114	119.5909
118	3	18	24	5.35	1.372	0.563	0.153	2.436944	-30	0	112.5	116.4313
119	5	24	6.5	0.14	0.257	0.201	0.055	1.278606	-24	-17.5	113.5	117.3222
120	5	24	12	0.35	0.363	0.288	0.075	1.260416	-24	-12	113.5	116.6286
121	5	25	20	0.87	0.565	0.411	0.074	1.374695	-23	-4	113.5	115.8760
122	5	28	15	1.18	0.651	0.392	0.1	1.660714	-20	-9	113.5	115.5995
123	5	23	32	0.32	0.413	0.17	0.063	2.429411	-25	6	113.5	116.4957
124	5	30	20.5	0.44	0.408	0.262	0.08	1.557251	-18	-3.5	113.5	114.9717
125	5	28	26.5	0.87	0.6	0.24	0.1	2.5	-20	2.5	113.5	115.2757
126	5	35.5	1	0.15	0.261	0.161	0.049	1.621118	-12.5	-23	113.5	116.4796
127	5	36	25.5	8.21	1.578	0.56	0.138	2.817857	-12	1.5	113.5	114.1424
128	5	41.5	2.5	1.01	0.56	0.273	0.125	2.051282	-6.5	-21.5	113.5	115.7011
129	5	41.5	11.5	0.72	0.552	0.32	0.092	1.725	-6.5	-12.5	113.5	114.3711
130	5	45.5	19.5	1.46	0.72	0.336	0.101	2.142857	-2.5	-4.5	113.5	113.6166
131	5	54.5	7.5	0.21	0.219	0.18	0.06	1.216666	6.5	-16.5	113.5	114.8771
132	5	57.5	6	0.9	0.482	0.324	0.127	1.487654	9.5	-18	113.5	115.3104
133	5	57.5	7.5	0.27	0.366	0.194	0.045	1.866597	9.5	-16.5	113.5	115.0858
134	5	59	5.75	0.2	0.241	0.2	0.066	1.205	11	-18.25	113.5	115.4829
135	5	59.5	13	0.69	0.491	0.381	0.095	1.288713	11.5	-11	113.5	114.6102
136	5	65	21	0.32	0.4	0.245	0.045	1.632653	17	-3	113.5	114.8052
137	5	69	13	0.49	0.51	0.281	0.081	1.814946	21	-11	113.5	115.9493
138	5	70.5	11.5	0.79	0.51	0.342	0.094	1.491228	22.5	-12.5	113.5	116.3819
139	5	71.5	14.5	0.38	0.36	[illegible]	0.084	1.722488	23.5	-9.5	113.5	116.2959
140	5	70	1	0.29	0.3	0.212	0.088	1.415094	22	-23	113.5	117.8781
141	5	77	6.5	0.26	0.355	0.208	0.07	1.706730	29	-17.5	113.5	118.4461
142	5	78	7	0.16	0.236	0.191	0.056	1.235602	30	-17	113.5	118.6222
143	5	80	8	0.37	0.491	0.184	0.065	2.668478	32	-16	113.5	119.0052
144	5	75.5	44	0.25	0.49	0.234	0.067	2.094017	27.5	20	113.5	118.4841
145	4	4.5	12	0.33	0.358	0.294	0.078	1.217687	-43.5	-12	113	121.6758
146	4	12	15.5	6.04	1.174	0.434	0.168	2.705069	-36	-8.5	113	118.9001
147	4	22.5	25	0.9	0.65	0.407	0.062	1.597051	-25.5	1	113	115.8458
148	4	23	10	0.4	0.529	0.211	0.091	2.507109	-25	-14	113	116.5761
149	4	2.5	11.5	0.02	0.121	0.111	0.05	1.090090	-45.5	-12.5	113	122.4561
150	4	28	4	0.18	0.362	0.154	0.057	2.350649	-20	-20	113	116.4860
151	4	25	5	0.36	0.32	0.248	0.061	1.290322	-23	-19	113	116.8717
152	4	29	13	0.33	0.452	0.21	0.068	2.152380	-19	-11	113	115.1129
153	4	27	14	0.67	0.371	0.274	0.125	1.354014	-21	-10	113	115.3689
154	4	32.5	14	0.94	0.641	0.343	0.084	1.868804	-15.5	-10	113	114.4956
155	4	36	5	0.23	0.34	0.258	0.093	1.317829	-12	-19	113	115.2128
156	4	31.5	29	0.65	0.511	0.332	0.088	1.539156	-16.5	5	113	114.3076
157	4	40.5	12.5	0.19	0.27	0.215	0.073	1.255813	-7.5	-11.5	113	113.8310
158	4	40.5	41.5	0.76	0.51	0.3	0.123	1.7	-7.5	17.5	113	114.5927

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENET X'(in)	RATION Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED MAX.	AREA MIN.	(IN)² AVG.
107	-0.07017	-0.04824	-0.21052	-0.14473	3	3.010858	-7.78947	-5.35526	0.041720	0.009365	0.025543
106	0.021929	-0.06140	0.065789	-0.18421	3	3.006370	2.434210	-6.81578	0.143901	0.008084	0.075993
109	0.028508	0.151315	0.085526	0.453947	3	3.035355	3.164473	16.79605	0.025345	0.007544	0.016444
110	-0.10087	-0.03070	-0.30263	-0.09210	3	3.016632	-11.1973	-3.40789	0.062408	0.009221	0.035815
111	0.166666	-0.07017	0.5	-0.21052	3	3.048658	18.5	-7.78947	0.013369	0.002778	0.008073
112	0.166666	-0.03508	0.5	-0.10526	3	3.043202	18.5	-3.89473	0.063092	0.009232	0.036162
113	0.162280	-0.14473	0.486842	-0.43421	3	3.070106	18.01315	-16.0657	0.044294	0.007486	0.025890
114	0.228070	-0.13157	0.684210	-0.39473	3	3.102250	25.31578	-14.6052	0.050913	0.005907	0.028410
115	0.254385	-0.13157	0.763157	-0.39473	3	3.120613	28.23684	-14.6052	0.054906	0.008516	0.031711
116	0.289473	0.030701	0.868421	0.092105	3	3.124522	32.13157	3.407894	0.009723	0.003850	0.006786
117	0.307017	-0.07894	0.921052	-0.23684	3	3.147130	34.07894	-8.76315	0.010969	0.004235	0.007602
118	-0.26666	0	-0.4	0	1.5	1.552417	-29.6	0	0.271992	0.030331	0.151161
119	-0.21145	-0.15418	-0.52863	-0.38546	2.5	2.584189	-23.4713	-17.1145	0.019799	0.004237	0.012018
120	-0.21145	-0.10572	-0.52863	-0.26431	2.5	2.568913	-23.4713	-11.7356	0.036299	0.007499	0.021899
121	-0.20264	-0.03524	-0.50660	-0.08810	2.5	2.552335	-22.4933	-3.91189	0.091449	0.011977	0.051713
122	-0.17621	-0.07929	-0.44052	-0.19823	2.5	2.546245	-19.5594	-8.80176	0.091785	0.014099	0.052942
123	-0.22026	0.070484	-0.55066	0.176211	2.5	2.565984	-24.4493	7.823788	0.039509	0.006026	0.022768
124	-0.15859	-0.03083	-0.39647	-0.07709	2.5	2.532417	-17.6035	-3.42290	0.042781	0.008388	0.025585
125	-0.17621	0.022026	-0.44052	0.055066	2.5	2.539113	-19.5594	2.444933	0.067672	0.011278	0.039475
126	-0.11013	-0.20264	-0.27533	-0.50660	2.5	2.565630	-12.2246	-22.4933	0.023811	0.004470	0.014141
127	-0.10572	0.013215	-0.26431	0.033039	2.5	2.514150	-11.7356	1.466960	0.462762	0.040469	0.251616
128	-0.05726	-0.18942	-0.14317	-0.47356	2.5	2.548482	-6.35682	-21.0264	0.062850	0.014029	0.038439
129	-0.05726	-0.11013	-0.14317	-0.27533	2.5	2.519187	-6.35682	-12.2246	0.060874	0.010145	0.035510
130	-0.02202	-0.03964	-0.05506	-0.09911	2.5	2.502570	-2.44493	-4.40088	0.112441	0.015773	0.064107
131	0.057268	-0.14537	0.143171	-0.36343	2.5	2.530332	6.356828	-16.1365	0.027224	0.007458	0.017341
132	0.083700	-0.15859	0.209251	-0.39647	2.5	2.539877	9.290748	-17.6035	0.055123	0.014524	0.034823
133	0.083700	-0.14537	0.209251	-0.36343	2.5	2.534930	9.290748	-16.1365	0.046670	0.005738	0.026204
134	0.096916	-0.16079	0.242290	-0.40198	2.5	2.543677	10.75770	-17.8480	0.023571	0.006455	0.015013
135	0.101321	-0.09691	0.253303	-0.24229	2.5	2.524453	11.24669	-10.7577	0.056496	0.010931	0.033713
136	0.149779	-0.02643	0.374449	-0.06607	2.5	2.528750	16.62555	-2.93392	0.055313	0.006222	0.030768
137	0.185022	-0.09691	0.462555	-0.24229	2.5	2.553950	20.53744	-10.7577	0.047054	0.007473	0.027264
138	0.198237	-0.11013	0.495594	-0.27533	2.5	2.563478	22.00440	-12.2246	0.065372	0.012049	0.038710
139	0.207048	-0.08370	0.517621	-0.20925	2.5	2.561584	22.98237	-9.29074	0.035188	0.008210	0.021699
140	0.193832	-0.20264	0.484581	-0.50660	2.5	2.596434	21.51541	-22.4933	0.025633	0.007519	0.016576
141	0.255506	-0.15418	0.638766	-0.38546	2.5	2.608946	28.36123	-17.1145	0.028891	0.005696	0.017294
142	0.264317	-0.14977	0.660792	-0.37444	2.5	2.612825	29.33920	-16.6255	0.022224	0.005273	0.013748
143	0.281938	-0.14096	0.704845	-0.35242	2.5	2.621261	31.29515	-15.6475	0.044277	0.005861	0.025069
144	0.242290	0.176211	0.605726	0.440528	2.5	2.609783	26.89427	19.55947	0.029024	0.003968	0.016496
145	-0.38495	-0.10619	-0.76991	-0.21238	2	2.153572	-42.7300	-11.7876	0.032908	0.007170	0.020039
146	-0.31858	-0.07522	-0.63716	-0.15044	2	2.104427	-35.3628	-8.34955	0.279654	0.040018	0.159836
147	-0.22566	0.008849	-0.45132	0.017699	2	2.050368	-25.0486	0.982300	0.112913	0.010770	0.061841
148	-0.22123	-0.12389	-0.44247	-0.24778	2	2.063294	-24.5575	-13.7522	0.034191	0.005881	0.020036
149	-0.40265	-0.11061	-0.80530	-0.22123	2	2.167364	-44.6946	-12.2787	0.003111	0.001285	0.002198
150	-0.17699	-0.17699	-0.35398	-0.35398	2	2.061700	-19.6460	-19.6460	0.024563	0.003867	0.014215
151	-0.20353	-0.16814	-0.40707	-0.33628	2	2.068526	-22.5929	-18.6637	0.045905	0.008750	0.027328
152	-0.16814	-0.09734	-0.33628	-0.19469	2	2.037398	-18.6637	-10.8053	0.037748	0.005678	0.021713
153	-0.18584	-0.08849	-0.37168	-0.17699	2	2.041928	-20.6283	-9.82300	0.041692	0.014047	0.027869
154	-0.13716	-0.08849	-0.27433	-0.17699	2	2.026471	-15.2256	-9.82300	0.087044	0.011406	0.049225
155	-0.10619	-0.16814	-0.21238	-0.33628	2	2.039165	-11.7876	-18.6637	0.019237	0.005261	0.012249
156	-0.14601	0.044247	-0.29203	0.088495	2	2.023145	-16.2079	4.911504	0.057454	0.009894	0.033674
157	-0.06637	-0.10176	-0.13274	-0.20353	2	2.014708	-7.36725	-11.2964	0.020245	0.005473	0.012859
158	-0.06637	0.154867	-0.13274	0.309734	2	2.028190	-7.36725	17.19026	0.048062	0.011591	0.029826

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Xi	Yi	Locations (1-8)	VEL. (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
107	23.09794	1801.214	587.4391	1194.326	0.048244	2	-1	6	1194.326	0.00E+00	0.00E+00	0.00E+00
108	4.868868	6461.769	745.6525	3603.711	0.091289	3	-1	7	3603.711	0.00E+00	0.00E+00	0.00E+00
109	17.63458	2124.255	856.0436	1490.149	0.029586	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
110	19.26552	2169.502	517.0608	1343.281	0.063458	2	-1	6	1343.281	0.00E+00	0.00E+00	0.00E+00
111	13.62459	2729.221	839.9641	1784.592	0.013440	4	-1	8	1784.592	0.00E+00	0.00E+00	0.00E+00
112	20.18665	2110.611	499.3831	1304.997	0.065223	4	-1	8	1304.997	0.00E+00	0.00E+00	0.00E+00
113	15.83611	2511.642	662.0640	1586.853	0.044544	4	-99	0	0	0.00E+00	4.45E-02	0.00E+00
114	12.67130	3097.974	615.9083	1856.941	0.045769	4	-99	0	0	0.00E+00	4.58E-02	0.00E+00
115	18.92045	2244.956	554.8641	1399.910	0.057507	4	-99	0	0	0.00E+00	5.75E-02	0.00E+00
116	14.73425	2351.594	1173.995	1762.794	0.012069	4	1	4	1762.794	0.00E+00	0.00E+00	0.00E+00
117	14.46850	2409.668	1180.360	1795.014	0.013518	4	-1	8	1795.014	0.00E+00	0.00E+00	1.35E-02
118	35.39252	855.7165	165.1326	510.4246	0.186963	1	1	1	510.4246	0.00E+00	0.00E+00	0.00E+00
119	11.64868	2701.241	849.9347	1775.588	0.017019	1	-99	0	0	0.00E+00	1.70E-02	0.00E+00
120	15.98194	2131.122	653.0919	1392.107	0.033358	1	-1	5	1392.107	0.00E+00	0.00E+00	3.34E-02
121	16.82345	2142.257	466.4005	1304.328	0.077692	1	-1	5	1304.328	0.00E+00	0.00E+00	0.00E+00
122	22.28829	1706.150	418.6311	1062.390	0.085829	1	-1	5	1062.390	0.00E+00	0.00E+00	8.58E-02
123	14.05463	2426.762	592.3387	1509.550	0.033072	1	1	1	1509.550	0.00E+00	0.00E+00	0.00E+00
124	17.19753	2008.750	591.9001	1300.325	0.039172	2	-1	6	1300.325	0.00E+00	0.00E+00	0.00E+00
125	22.03885	1702.565	444.1097	1073.337	0.063933	1	1	1	1073.337	0.00E+00	0.00E+00	0.00E+00
126	10.60744	2929.817	835.6170	1882.717	0.019335	2	-99	0	0	1.93E-02	0.00E+00	0.00E+00
127	32.62906	1327.322	213.4545	770.3883	0.433035	2	1	2	770.3883	0.00E+00	0.00E+00	0.00E+00
128	26.27503	1444.178	468.9887	956.5836	0.066147	2	-99	0	0	6.61E-02	0.00E+00	0.00E+00
129	20.27574	1801.758	469.9841	1135.871	0.055992	2	-99	0	0	0.00E+00	0.00E+00	5.60E-02
130	22.77438	1671.632	383.1620	1027.397	0.102698	2	-1	6	1027.397	0.00E+00	0.00E+00	0.00E+00
131	12.10952	2490.932	943.2835	1717.107	0.024688	3	-99	0	0	0.00E+00	2.47E-02	0.00E+00
132	25.84457	1423.472	523.4997	973.4859	0.059985	3	-99	0	0	0.00E+00	6.00E-02	0.00E+00
133	10.30356	3094.975	642.6223	1868.799	0.034545	3	-99	0	0	0.00E+00	3.45E-02	0.00E+00
134	13.32166	2328.255	881.4057	1604.830	0.021975	3	-99	0	0	0.00E+00	2.20E-02	0.00E+00
135	20.46648	1761.671	513.9331	1137.802	0.053751	3	-1	7	1137.802	0.00E+00	0.00E+00	5.38E-02
136	10.40035	3089.315	600.1041	1844.709	0.040415	3	-1	7	1844.709	0.00E+00	0.00E+00	0.00E+00
137	17.97229	2002.800	503.8761	1253.338	0.042047	4	-1	8	1253.338	0.00E+00	0.00E+00	4.20E-02
138	20.40783	1796.257	505.2853	1150.771	0.062242	4	-99	0	0	0.00E+00	0.00E+00	6.22E-02
139	17.51195	1953.278	655.7628	1304.520	0.033[illegible]	4	-1	8	1304.520	0.00E+00	0.00E+00	3.39E-02
140	17.49476	1905.518	759.5112	1332.514	0.026457	4	-99	0	0	2.65E-02	0.00E+00	0.00E+00
141	15.03395	2270.479	671.8461	1471.162	0.026188	4	-99	0	0	0.00E+00	2.62E-02	0.00E+00
142	11.63732	2687.100	913.5682	1800.334	0.019721	4	-99	0	0	0.00E+00	1.97E-02	0.00E+00
143	14.75896	2408.739	528.6445	1468.691	0.037205	4	-99	0	0	0.00E+00	3.72E-02	0.00E+00
144	15.15484	2346.872	527.7136	1437.292	0.024601	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
145	16.46747	1812.970	578.1618	1195.566	0.027012	-99	-1	0	0	0.00E+00	0.00E+00	2.70E-02
146	37.78859	1002.214	233.1801	617.6973	0.255436	1	-1	5	617.6973	0.00E+00	0.00E+00	0.00E+00
147	14.55328	2075.736	356.2714	1216.004	0.074928	1	1	1	1216.004	0.00E+00	0.00E+00	0.00E+00
148	19.96370	1563.983	417.7546	990.8688	0.027136	1	-99	0	0	0.00E+00	2.71E-02	0.00E+00
149	9.096935	2542.808	1310.545	1926.677	0.002638	-99	-99	0	0	0.00E+00	0.00E+00	2.64E-03
150	12.66208	2220.010	554.9192	1387.465	0.017098	1	-99	0	0	1.71E-02	0.00E+00	0.00E+00
151	13.17318	2115.146	610.2045	1362.675	0.033586	1	-99	0	0	3.36E-02	0.00E+00	0.00E+00
152	15.19776	1927.601	465.6345	1196.618	0.027035	1	-1	5	1196.618	0.00E+00	0.00E+00	2.70E-02
153	24.04020	1223.038	540.8690	881.9536	0.040456	1	-1	5	881.9536	0.00E+00	0.00E+00	4.05E-02
154	19.09568	1638.468	356.8650	997.6666	0.064207	2	-1	6	997.6666	0.00E+00	0.00E+00	6.42E-02
155	18.77629	1525.173	576.8624	1051.018	0.016550	2	-99	0	0	1.66E-02	0.00E+00	0.00E+00
156	19.30245	1580.339	422.4708	1001.405	0.044565	2	1	2	1001.405	0.00E+00	0.00E+00	0.00E+00
157	14.77502	1812.421	679.5609	1245.991	0.016208	2	-1	6	1245.991	0.00E+00	0.00E+00	1.62E-02
158	25.48047	1231.671	423.8830	827.7772	0.043072	2	99	0	0	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
107	4.82E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
108	9.13E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-02	0.00E+00
110	0.00E+00	6.35E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
111	1.34E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
112	6.52E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
113	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
114	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
115	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
116	0.00E+00	1.21E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
117	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
118	0.00E+00	1.87E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
119	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
121	7.77E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
123	0.00E+00	0.00E+00	3.31E-02	0.00E+00	0.00E+00	0.00E+00
124	0.00E+00	3.92E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
125	0.00E+00	6.39E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
126	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
127	0.00E+00	4.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
128	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
130	1.03E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
136	0.00E+00	4.04E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
139	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
141	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.46E-02
145	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
146	2.55E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
147	0.00E+00	7.49E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
148	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
149	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
150	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
151	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
155	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
156	0.00E+00	0.00E+00	4.46E-02	0.00E+00	0.00E+00	0.00E+00
157	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
158	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.31E-02	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES X (in)	POSITION COORDINATES Y (in)	POSITION COORDINATES Z (in)	PATH R (in)
159	4	38.5	23	0.4	0.32	0.298	0.1	1.944537	-9.5	-1	113	113.4030
160	3	38.5	35	0.42	0.275	0.252	0.082	1.091269	-9.5	11	112.5	113.4250
161	4	36	2.5	2.25	0.798	0.489	0.131	1.631901	-12	-21.5	113	115.6514
162	4	29.5	5.5	1.5	0.876	0.27	0.08	3.244444	-18.5	-18.5	113	115.9892
163	4	44	12	0.34	0.34	0.308	0.066	1.103896	-4	-12	113	113.7057
164	4	45	19.5	0.73	0.628	0.283	0.088	2.219081	-3	-4.5	113	113.1293
165	4	50	24.5	0.31	0.337	0.189	0.137	1.783068	2	0.5	113	113.0188
166	4	59	5.5	1.08	0.698	0.358	0.082	1.949720	11	-18.5	113	115.0315
167	4	[illegible]	12	1.2	0.574	0.312	0.156	1.839743	43	-12	113	121.4989
168	4	56	14.5	0.44	0.46	0.204	0.145	2.254901	8	-9.5	113	113.6804
169	4	56	14.5	0.71	0.559	0.295	0.155	1.894915	8	-9.5	113	113.6804
170	4	59	3	0.31	0.296	0.228	0.074	1.298245	11	-16	113	114.6560
171	4	73	5	2.3	0.852	0.348	0.199	2.448275	25	-19	113	117.2817
172	4	62.5	14	0.41	0.558	0.248	0.154	2.25	14.5	-10	113	114.3645
173	4	64.5	7	0.46	0.526	0.293	0.081	1.795221	16.5	-17	113	115.4567
174	4	66.5	6	0.21	0.291	0.204	0.088	1.426470	18.5	-18	113	115.9105
175	4	66	7	0.03	0.099	0.061	0.051	1.622950	18	-17	113	115.6805
176	4	55	5	1.02	0.63	0.306	0.071	2.058823	7	-19	113	114.7998
177	4	80.5	13	0.2	0.395	0.21	0.052	1.880952	32.5	-11	113	118.0942
178	4	79	20	0.02	0.111	0.069	0.048	1.608695	31	-4	113	117.2433
179	4	64	29	2.45	0.893	0.573	0.093	1.659851	16	5	113	114.2365
180	4	61	15.5	0.75	0.778	0.326	0.069	2.386503	13	-8.5	113	114.0624
181	4	51.5	20.5	0.9	0.642	0.27	0.262	2.377777	3.5	-3.5	113	113.1083
182	4	48	5	0.18	0.3	0.226	0.045	1.327433	0	-19	113	114.5862
183	4	58.5	33.5	0.48	0.552	0.251	0.076	2.199203	10.5	9.5	113	113.8837
184	4	79.5	27.5	0.16	0.365	0.175	0.055	2.085714	31.5	3.5	113	117.3605
185	4	79.5	8	0.19	0.371	0.166	0.064	2.234939	31.5	-16	113	118.3944
186	4	70.5	40	0.36	0.381	0.276	0.061	1.380434	22.5	16	113	116.3239
187	4	77	4	0.35	0.384	0.249	0.09	1.542168	29	-20	113	118.3638
188	4	75	5.5	0.28	0.32	0.178	0.062	1.797752	27	-18.5	113	117.6445
189	4	58.5	34	0.21	0.327	0.187	0.082	[illegible]	10.5	10	113	113.9265
190	4	49	40	0.43	0.638	0.326	0.055	[illegible]	1	16	113	114.1315
191	4	45	24.5	0.84	0.404	[illegible]	0.14	[illegible]	-3	0.5	113	113.0403
192	4	52	4	0.44	0.454	0.227	0.057		4	-20	113	114.8259
193	3	20.5	18.5	4.29	1.21	0.616	0.135	1.96426	-27.5	-5.5	112.5	115.9428
194	3	22	7.5	0.34	0.376	0.308	0.065	1.220779	-26	-16.5	112.5	116.6383
195	3	26	9.5	0.12	0.228	0.139	0.065	1.640287	-22	-14.5	112.5	115.5443
196	3	30	3	2.71	0.859	0.375	0.161	2.290666	-18	-21	112.5	115.8501
197	3	27.5	14.5	0.1	0.218	0.176	0.056	1.238636	-20.5	-9.5	112.5	114.7464
198	3	15.5	31	0.42	0.367	0.275	0.106	1.334545	-32.5	7	112.5	117.3094
199	3	18	35.25	0.21	0.358	0.216	0.088	1.657407	-30	11.25	112.5	116.9735
200	3	26	34.75	0.17	0.315	0.186	0.063	1.693548	-22	10.75	112.5	115.1338
201	3	32	38.5	1.05	0.778	0.353	0.124	2.203966	-16	14.5	112.5	114.5534
202	3	42	24.5	0.36	0.465	0.28	0.059	1.660714	-6	0.5	112.5	[illegible]
203	3	40.5	12	3.8	1.025	0.55	0.178	1.863636	-7.5	-12	112.5	113.3865
204	3	53.5	28.5	0.26	0.475	0.24	0.044	1.979166	5.5	4.5	112.5	112.7242
205	3	53	37.75	0.19	0.445	0.19	0.058	2.342105	5	13.75	112.5	113.4473
206	3	64	38	0.31	0.433	0.234	0.074	1.850427	16	14	112.5	114.4912
207	3	77	12	0.38	0.505	0.292	0.055	1.729452	29	-12	112.5	116.7957
208	3	81	21	0.42	0.371	0.225	0.109	1.648888	33	-3	112.5	[illegible]
209	3	86	12.5	0.47	0.4	0.301	0.088	1.328903	38	-11.5	112.5	119.3000
210	3	64	20.5	0.15	0.496	0.17	0.045	2.917647	16	-3.5	112.5	113.6859

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENETRATION X'(in)	Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED AREA (IN)² MAX.	MIN.	AVG.
159	-0.08407	-0.00884	-0.16814	-0.01769	2	2.007133	-9.33185	-0.98230	0.031113	0.009723	0.020418
160	-0.08444	0.097777	-0.12666	0.146666	1.5	1.512466	-3.37333	10.85333	0.039840	0.011879	0.025860
161	-0.10619	-0.19026	-0.21238	-0.38053	2	2.046927	-11.7876	-21.1194	0.133599	0.021931	0.077765
162	-0.16371	-0.16371	-0.32743	-0.32743	2	2.052906	-18.1725	-18.1725	0.145846	0.013319	0.079582
163	-0.03539	-0.10619	-0.07079	-0.21238	2	2.012491	-3.92920	-11.7876	0.040070	0.007778	0.023924
164	-0.02654	-0.03982	-0.05309	-0.07964	2	2.002289	-2.94690	-4.42035	0.064525	0.009041	0.036783
165	0.017699	0.004424	0.035398	0.008849	2	2.000332	1.964601	0.491150	0.017600	0.007155	0.012378
166	0.097345	-0.16371	0.194690	-0.32743	2	2.035956	10.80530	-18.1725	0.102448	0.012035	0.057241
167	0.380530	-0.10619	0.761061	-0.21238	2	2.150424	42.23893	-11.7876	0.059834	0.016261	0.038047
168	0.070796	-0.08407	0.141592	-0.16814	2	2.012043	7.858407	-9.33185	0.023603	0.007440	0.015521
169	0.070796	-0.08407	0.141592	-0.16814	2	2.012043	7.858407	-9.33185	0.035630	0.009879	0.022755
170	0.097345	-0.14159	0.194690	-0.28318	2	2.029309	10.80530	-15.7168	0.032585	0.008146	0.020365
171	0.221238	-0.16814	0.442477	-0.33628	2	2.075782	24.55752	-18.6637	0.089901	0.020998	0.055450
172	0.128318	-0.08843	0.256637	-0.17699	2	2.024151	14.24336	-9.82300	0.059058	0.005715	0.032387
173	0.146017	-0.15044	0.292035	-0.30088	2	2.043481	16.20796	-16.6991	0.044174	0.006802	0.025488
174	0.163716	-0.15929	0.327433	-0.31858	2	2.051513	18.17256	-17.6814	0.018562	0.005613	0.012087
175	0.159292	-0.15044	0.318584	-0.30088	2	2.047444	17.68141	-16.6991	0.004575	0.002357	0.003466
176	0.061946	-0.16814	0.123893	-0.33628	2	2.031855	6.876106	-18.6637	0.111747	0.012593	0.062170
177	0.287610	-0.09734	0.575221	-0.19469	2	2.090163	31.92477	-10.8053	0.029917	0.003938	0.016927
178	0.274336	-0.03539	0.548672	-0.07079	2	2.075103	30.45132	-3.92920	0.003241	0.001401	0.002321
179	0.141592	0.044247	0.283185	0.088495	2	2.021886	15.71681	4.911504	0.204916	0.021340	0.113128
180	0.115044	-0.07522	0.230088	-0.15044	2	2.018805	12.76991	-8.34955	0.084548	0.007498	0.046023
181	0.030973	-0.03097	0.061946	-0.06194	2	2.001917	3.438053	-3.43805	0.026719	0.010904	0.018812
182	0	-0.16814	0	-0.33628	2	2.028074	0	-18.6637	0.031113	0.004667	0.017890
183	0.092920	0.084070	0.185840	0.168141	2	2.015640	10.31415	9.331858	0.049127	0.006763	0.027945
184	0.278761	0.030973	0.557522	0.061946	2	2.077177	30.94247	3.438053	0.022628	0.003409	0.013019
185	0.278761	-0.14159	0.557522	-0.28318	2	2.095477	30.94247	-15.7168	0.023092	0.003983	0.013537
186	0.199115	0.141592	0.398230	0.283185	2	2.058830	22.10176	15.71681	0.045905	0.007349	0.026627
187	0.256637	-0.17699	0.513274	-0.35398	2	2.094935	28.48672	-19.6460	0.030249	0.007089	0.018669
188	0.238938	-0.16371	0.477876	-0.32743	2	2.082205	26.52212	-18.1725	0.035128	0.006806	0.020967
189	0.092920	0.088495	0.185840	0.176991	2	2.016398	10.31415	9.823008	0.019920	0.004995	0.012457
190	0.008849	0.141592	0.017699	0.283185	2	2.020026	0.982300	15.71681	0.060813	0.005242	0.033028
191	-0.02654	0.004424	-0.05309	0.008849	2	2.000724	-2.94690	0.491150	0.046670	0.015975	0.031323
192	0.035398	-0.17699	0.070796	-0.35398	2	2.032317	3.929203	-19.6460	0.060044	0.007538	0.033791
193	-0.24444	-0.04888	-0.36666	-0.07333	1.5	1.545904	-27.1333	-5.42666	0.247182	0.027578	0.137380
194	-0.23111	-0.14666	-0.34666	-0.22	1.5	1.555177	-25.6533	-16.28	0.040687	0.007033	0.023860
195	-0.19555	-0.12888	-0.29333	-0.19333	1.5	1.540591	-21.7066	-14.3066	0.014360	0.004093	0.009227
196	-0.16	-0.18666	-0.24	-0.28	1.5	1.544668	-17.76	-20.72	0.130929	0.024539	0.077734
197	-0.18222	-0.08444	-0.27333	-0.12666	1.5	1.529952	-20.2266	-9.37333	0.013890	0.003568	0.008729
198	-0.28888	0.062222	-0.43333	0.093333	1.5	1.564125	-32.0666	6.906666	0.030820	0.008901	0.019861
199	-0.26666	0.1	-0.4	0.15	1.5	1.559647	-29.6	11.1	0.018562	0.004562	0.011562
200	-0.19555	0.095555	-0.29333	0.143333	1.5	1.535118	-21.7066	10.60666	0.020989	0.004197	0.012593
201	-0.14222	0.128888	-0.21333	0.193333	1.5	1.527379	-15.7866	14.30666	0.065866	0.010497	0.038182
202	-0.05333	0.004444	-0.08	0.006666	1.5	1.502146	-5.92	0.493333	0.047461	0.006022	0.026741
203	-0.06666	-0.10666	-0.1	-0.16	1.5	1.511620	-7.4	-11.84	0.166057	0.028837	0.097447
204	0.048888	0.04	0.073333	0.06	1.5	1.502989	5.426666	-4.44	0.045963	0.004257	0.025110
205	0.044444	0.122222	0.066666	0.183333	1.5	1.512631	4.933333	13.56666	0.025481	0.003321	0.014401
206	0.142222	0.124444	0.213333	0.186666	1.5	1.526550	15.78666	13.81333	0.032585	0.005568	0.019077
207	0.257777	-0.10666	0.386666	-0.16	1.5	1.557276	28.61333	-11.84	0.053742	0.005853	0.029797
208	0.293333	-0.02666	0.44	-0.04	1.5	1.563713	32.56	-2.96	0.036299	0.008805	0.022552
209	0.337777	-0.10222	0.506666	-0.15333	1.5	1.590667	37.49333	-11.3466	0.041544	0.009139	0.025341
210	0.142222	-0.03111	0.213333	-0.04666	1.5	1.515812	15.78666	-3.45333	0.025928	0.002352	0.014140

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Locations (1-6) X1	Y1		VEL (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
159	19.59009	1427.329	596.5706	1011.950	0.027713	2	-1	6	1011.950	0.00E+00	0.00E+00	0.00E+00
160	16.24105	1339.664	540.5762	940.1204	0.027033	2	1	2	940.1204	0.00E+00	0.00E+00	0.00E+00
161	28.93305	1182.947	305.0821	744.0149	0.114613	2	-99	0	0	1.15E-01	0.00E+00	0.00E+00
162	18.84829	1716.135	285.0958	1000.615	0.102761	1	-99	0	0	1.03E-01	0.00E+00	0.00E+00
163	14.21126	1953.145	571.1937	1262.169	0.029381	2	-1	6	1262.169	0.00E+00	0.00E+00	2.94E-02
164	19.84564	1568.105	359.1431	963.6242	0.048161	2	-1	6	963.6242	0.00E+00	0.00E+00	0.00E+00
165	25.04424	1124.290	572.3957	848.3429	0.018005	3	1	3	848.3429	0.00E+00	0.00E+00	0.00E+00
166	18.86733	1674.202	335.9517	1005.077	0.074318	3	-99	0	0	7.43E-02	0.00E+00	0.00E+00
167	31.53911	1076.816	405.3230	741.0699	0.060885	99	-1	0	0	0.00E+00	0.00E+00	6.09E-02
168	28.34694	1082.166	455.2519	768.7093	0.023157	3	-1	7	768.7093	0.00E+00	0.00E+00	2.32E-02
169	31.20190	1029.369	393.3338	711.3518	0.034579	3	-1	7	711.3518	0.00E+00	0.00E+00	3.46E-02
170	15.22150	1803.763	637.7267	1220.745	0.025909	3	-99	0	0	0.00E+00	2.59E-02	0.00E+00
171	41.47876	873.6524	293.5275	583.5900	0.091898	4	-99	0	0	9.19E-02	0.00E+00	0.00E+00
172	12.65937	2280.232	395.6386	1337.935	0.037556	3	-1	7	1337.935	0.00E+00	0.00E+00	3.76E-02
173	18.04753	1694.362	416.5151	1055.438	0.033240	3	-99	0	0	0.00E+00	3.32E-02	0.00E+00
174	17.37289	1596.930	651.2207	1124.075	0.016161	4	-99	0	0	0.00E+00	1.62E-02	0.00E+00
175	8.654659	2400.620	1459.737	1930.179	0.003964	3	-99	0	0	0.00E+00	3.96E-03	0.00E+00
176	16.40653	1862.378	362.2482	1112.313	0.077678	3	-99	0	0	7.77E-02	0.00E+00	0.00E+00
177	11.81486	2402.839	525.1453	1463.992	0.020046	4	-1	8	1463.992	0.00E+00	0.00E+00	2.00E-02
178	8.615945	2537.704	1353.255	1945.479	0.002663	4	-1	8	1945.479	0.00E+00	0.00E+00	0.00E+00
179	21.65675	1515.470	277.8248	896.6477	0.150403	3	1	3	896.6477	0.00E+00	0.00E+00	0.00E+00
180	16.29600	1893.547	307.7359	1100.641	0.056516	3	-1	7	1100.641	0.00E+00	0.00E+00	0.00E+00
181	47.84138	691.7526	353.2039	522.4783	0.032194	3	-1	7	522.4783	0.00E+00	0.00E+00	0.00E+00
182	10.06121	2618.157	631.0505	1624.603	0.020021	3	-99	0	0	2.00E-02	0.00E+00	0.00E+00
183	17.17627	1759.105	397.6012	1078.353	0.035438	3	1	3	1078.353	0.00E+00	0.00E+00	0.00E+00
184	12.28972	2293.112	554.5973	1423.855	0.015597	4	1	4	1423.855	0.00E+00	0.00E+00	0.00E+00
185	14.03461	2060.247	551.4725	1305.860	0.016987	4	-99	0	0	0.00E+00	1.70E-02	0.00E+00
186	13.51974	2107.706	533.4746	1320.590	0.032549	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
187	18.74697	1595.101	537.3059	1066.203	0.025549	4	-99	0	0	2.55E-02	0.00E+00	0.00E+00
188	13.35408	2099.863	613.2284	1356.545	0.026005	4	-99	0	0	2.60E-02	0.00E+00	0.00E+00
189	16.85676	1662.126	588.9976	1125.561	0.016183	3	1	3	1125.561	0.00E+00	0.00E+00	0.00E+00
190	13.01925	2245.628	357.2682	1301.448	0.038314	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
191	26.81728	1106.334	495.0967	800.7157	[illegible]	2	1	2	800.7157	0.00E+00	0.00E+00	0.00E+00
192	13.02103	2196.239	463.2271	1329.733	0.040057	3	-99	0	0	4.01E-02	0.00E+00	0.00E+00
193	31.22717	936.9769	180.8798	558.9284	0.164166	1	-1	5	558.9284	0.00E+00	0.00E+00	0.00E+00
194	14.24946	1628.328	436.5522	1032.440	0.024033	1	-99	0	0	0.00E+00	2.40E-02	0.00E+00
195	13.00518	1616.861	630.8217	1123.841	0.009233	1	-99	0	0	0.00E+00	9.23E-03	0.00E+00
196	34.86219	820.5388	233.7349	527.1369	0.097805	2	-99	0	0	9.78E-02	0.00E+00	0.00E+00
197	11.45591	1798.703	649.0203	1223.862	0.008879	1	-1	5	1223.862	0.00E+00	0.00E+00	[illegible]
198	21.14689	1133.225	446.4741	789.8499	0.022712	1	1	1	789.8499	0.00E+00	0.00E+00	0.00E+00
199	18.16212	1300.169	453.8893	877.0292	0.012609	1	1	1	877.0292	0.00E+00	0.00E+00	0.00E+00
200	13.4988	1650.795	493.7029	1072.248	0.012480	1	1	1	1072.248	0.00E+00	0.00E+00	0.00E+00
201	27.49986	989.6602	249.6420	619.6511	0.044545	2	99	0	0	0.00E+00	0.00E+00	0.00E+00
202	13.46199	1706.032	362.6909	1034.361	0.025494	2	1	2	1034.361	0.00E+00	0.00E+00	0.00E+00
203	38.99546	748.8627	201.4532	475.1580	0.123621	2	-1	6	475.1580	0.00E+00	0.00E+00	1.24E-01
204	10.35415	2126.765	357.0992	1241.932	0.022107	3	1	3	1241.932	0.00E+00	0.00E+00	0.00E+00
205	13.19337	1737.085	376.8097	1056.947	0.013749	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
206	16.24978	1456.973	387.2661	922.1198	0.019571	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
207	12.75269	1847.542	350.2659	1098.904	0.028540	4	-1	8	1098.904	0.00E+00	0.00E+00	2.86E-02
208	18.62907	1280.938	442.7714	861.8547	0.024783	4	1	8	861.8547	0.00E+00	0.00E+00	0.00E+00
209	18.54636	1319.515	423.8689	871.6924	0.028049	99	-1	0	0	0.00E+00	0.00E+00	2.80E-02
210	10.60798	2104.587	347.9085	1226.247	0.012593	3	-1	7	1226.247	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
159	0.00E+00	2.77E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160	0.00E+00	0.00E+00	0.00E+00	2.70E-02	0.00E+00	0.00E+00
161	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
162	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
163	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
164	4.82E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
165	0.00E+00	1.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
166	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
167	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
168	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
170	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
171	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
172	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
173	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
174	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
175	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
176	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
177	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
178	2.66E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
179	0.00E+00	0.00E+00	1.50E-01	0.00E+00	0.00E+00	0.00E+00
180	5.65E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
181	0.00E+00	3.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
182	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
183	0.00E+00	0.00E+00	0.00E+00	3.54E-02	0.00E+00	0.00E+00
184	0.00E+00	1.56E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
185	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
186	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-02	0.00E+00
187	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
188	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
189	0.00E+00	0.00E+00	0.00E+00	1.62E-02	0.00E+00	0.00E+00
190	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-02	0.00E+00
191	0.00E+00	4.60E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
192	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
193	1.64E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
194	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
195	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
196	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
197	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
198	0.00E+00	0.00E+00	2.27E-02	0.00E+00	0.00E+00	0.00E+00
199	0.00E+00	0.00E+00	0.00E+00	1.26E-02	0.00E+00	0.00E+00
200	0.00E+00	0.00E+00	0.00E+00	1.25E-02	0.00E+00	0.00E+00
201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.45E-02	0.00E+00
202	0.00E+00	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
203	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
204	0.00E+00	0.00E+00	2.21E-02	0.00E+00	0.00E+00	0.00E+00
205	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-02	0.00E+00
206	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-02	0.00E+00
207	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
208	0.00E+00	2.48E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
209	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
210	0.00E+00	1.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THI (in)	L/D	POSITION COORDINATES, X (in)	Y (in)	Z (in)	PATH R (in)
211	3	1	16.5	0.3	0.361	0.297	[illegible]	1.215488	-47	-7.5	112.5	122.1535
212	3	2	11	0.03	0.226	0.174	0.048	1.298850	-46	-13	112.5	122.2944
213	3	15.5	25	[illegible]	0.274	0.228	0.041	1.201754	-32.5	1	112.5	117.1046
214	3	19	16	[illegible]	0.563	0.39	0.085	1.4435[illegible]	-29	8	112.5	116.4527
215	3	17	1.5	1.16	0.595	0.437	0.144	1.361556	-31	-22.5	112.5	118.8423
216	3	21	6.5	0.14	0.267	0.185	0.063	1.443243	-27	-17.5	112.5	117.0106
217	3	3	24	0.04	0.194	0.19	0.025	1.021052	-45	-1	112.5	121.1703
218	3	12	46	0.18	0.337	0.182	0.062	1.851640	-36	22	112.5	120.1509
219	3	13.5	40	0.02	0.205	0.112	0.036	1.830357	-32.5	16	112.5	118.1864
220	3	20	41	0.09	0.326	0.138	0.044	2.362318	-28	17	112.5	117.1718
221	3	20.25	43.5	0.02	0.21	0.129	0.026	1.627906	-27.75	19.5	112.5	117.5013
222	3	24	36	.03	0.225	0.126	0.023	1.785714	-24	12	112.5	115.6557
223	3	25	36	0.04	0.214	0.13	0.041	1.646153	-29	12	112.5	115.4523
224	3	29	24.5	0.21	0.388	0.256	0.062	1.515625	-19	0.5	112.5	114.0942
225	3	25.5	29.5	0.12	0.279	0.19	0.056	1.468421	-22.5	5.5	112.5	114.8596
226	3	28.5	17.5	0.08	0.189	0.171	0.045	1.105263	-19.5	-6.5	112.5	114.3623
227	3	32.5	16	0.08	0.393	0.109	0.056	3.605504	-15.5	8	112.5	113.8441
228	3	34	20.5	0.12	0.35	0.05	0.026	7	[illegible]	-3.5	112.5	113.4217
229	3	31.5	32.75	0.02	0.18	0.118	0.035	1.525423	[illegible]	8.75	112.5	114.0397
230	3	1	0.75	0.28	0.461	0.173	0.059	2.[illegible]4739	[illegible]	-23.25	112.5	124.1201
231	3	37.5	14	0.25	0.429	0.277	0.05	1.548736	[illegible]	-10	112.5	113.4305
232	2	36	29	0.29	0.368	0.26	0.07	1.415384	12	5	112	112.7519
233	2	39	33	0.79	0.574	0.311	0.205	1.845659	-8	9	112	112.7208
234	2	42	36	0.01	0.152	0.083	0.047	1.831325	-6	12	112	112.8007
235	2	33	41	0.1	0.341	0.273	0.03	1.249084	[illegible]	17	112	114.2716
236	2	47	40	0.02	0.164	0.105	0.025	1.561904	[illegible]	16	112	113.1415
237	2	47.5	43.5	0.29	0.431	0.159	0.089	2.710691	-0.[illegible]	[illegible]	112	113.6859
238	2	48.25	28	0.59	0.36	0.342	0.106	1.052631	0.25	[illegible]	112	112.0716
239	2	52.5	30	0.21	0.5	0.221	0.052	2.262443	4.5	5	112	112.2508
240	2	54	42.75	1.3	0.985	0.378	0.098	2.605820	6	.5	112	113.7170
241	2	56.5	14.5	0.04	0.159	0.151	0.036	1.052980	8.5	5	112	112.7231
242	2	57.5	37.25	2.78	0.658	0.423	0.148	1.555555	9.5	.25	112	113.1804
243	2	60	12.5	0.66	[illegible]	[illegible]	0.09	1.972881	12	-11.5	112	113.2265
244	2	60	10	0.21	[illegible]	[illegible]	0.082	1.097744	12	-14	112	113.5077
245	2	62.5	15.5	0.56	0.532	0.3	0.089	1.773333	14.5	-8.5	112	113.2541
246	2	64	18	1.05	0.562	0.405	0.108	1.387654	16	6	112	113.2960
247	2	62	42	0.19	0.334	0.31	0.036	1.067741	14	18	112	114.2978
248	2	67.5	17.25	0.5	0.435	0.287	0.085	1.515679	19.5	-6.75	112	113.8850
249	2	70	7	0.14	0.411	0.163	0.041	2.521472	22	-17	112	115.3993
250	2	68	28	0.08	0.25	0.178	0.046	1.404494	20	4	112	113.8419
251	2	69	37.5	0.18	0.372	0.214	0.039	1.738317	21	13.5	112	114.7486
252	2	71	34.5	1.38	0.786	0.41	0.164	1.917073	23	10.5	112	114.8183
253	2	70.5	8	0.19	0.371	0.202	0.052	1.836633	22.5	-16	112	115.3527
254	2	70	1	0.2	0.306	0.195	0.074	1.569230	22	-23	112	116.4345
255	2	70.5	38	0.6	0.432	0.259	0.085	1.667953	22.5	14	112	115.0923
256	2	73	15	1.68	0.601	0.59	0.105	1.018644	25	9	112	115.1086
257	2	74	10.5	0.35	0.319	0.216	0.072	1.476851	26	-13.5	112	115.7680
258	2	72	32.25	0.26	0.204	0.116	0.04	1.758620	24	8.25	112	114.8992
259	2	75	26	0.58	0.354	0.308	0.104	1.149350	27	2	112	115.2058
260	2	75.5	20	0.27	0.269	0.189	0.054	1.423280	27.5	-4	112	115.3960
261	2	74	10.5	0.26	0.2	0.16	0.05	1.25	26	-13.5	112	115.7680
262	2	70	39	0.92	0.707	0.326	0.071	2.168711	[illegible]	15	112	115.1[illegible]16

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENETRATION X'(in)	Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED MAX.	AREA MIN.	(IN)^2 AVG.
211	-0.41777	-0.06666	-0.62666	-0.1	1.5	1.628714	-46.3733	-7.4	0.031534	0.006464	0.018999
212	-0.40888	-0.11555	-0.61333	-0.17333	1.5	1.629792	-45.3866	-12.8266	0.004861	0.001032	0.002947
213	-0.28888	0.008888	-0.43333	0.013333	1.5	1.561395	-32.0666	0.986666	0.024967	0.007381	0.016174
214	-0.25777	-0.07111	-0.38666	-0.10666	1.5	1.552703	-28.6133	-7.89333	0.084190	0.012710	0.048450
215	-0.27555	-0.2	-0.41333	-0.3	1.5	1.584564	-30.5866	-22.2	0.062659	0.015164	0.038912
216	-0.24	-0.15555	-0.36	-0.23333	1.5	1.560142	-26.64	-17.2666	0.017285	0.004078	0.010682
217	-0.4	-0.00888	-0.6	-0.01333	1.5	1.615604	-44.4	-0.98666	0.012445	0.001603	0.007024
218	-0.32	0.195555	-0.48	0.293333	1.5	1.602012	-35.52	21.70666	0.022582	0.004154	0.013368
219	-0.28888	0.142222	-0.43333	0.213333	1.5	1.575845	-32.0666	15.78666	0.004321	0.000758	0.002540
220	-0.24888	0.151111	-0.37333	0.226666	1.5	1.562291	-27.6266	16.77333	0.015910	0.002147	0.009028
221	-0.24666	0.173333	-0.37	0.26	1.5	1.566684	-27.38	19.24	0.005983	0.000740	0.003962
222	-0.21333	0.106666	-0.32	0.16	1.5	1.542076	-23.68	11.84	0.010145	0.001037	0.005591
223	-0.20444	0.106666	-0.30666	0.16	1.5	1.539364	-22.6933	11.84	0.007588	0.001453	0.004521
224	-0.16888	0.004444	-0.25333	0.006666	1.5	1.521256	-18.7466	0.493333	0.026346	0.004209	0.015278
225	-0.2	0.048888	-0.3	0.073333	1.5	1.531462	-22.2	5.426666	0.016668	0.003345	0.010006
226	-0.17333	-0.05777	-0.26	-0.08666	1.5	1.524831	-19.24	-6.41333	0.013828	0.003292	0.008560
227	-0.13777	-0.07111	-0.20666	-0.10666	1.5	1.517922	-15.2933	-7.89333	0.011112	0.001583	0.006347
228	-0.12444	-0.03111	-0.18666	-0.04666	1.5	1.512290	-13.8133	-3.45333	0.035900	0.002666	0.019283
229	-0.14666	0.077777	-0.22	0.116666	1.5	1.520529	-16.28	8.633333	0.004444	0.000864	0.002654
230	-0.41777	-0.20666	-0.62666	-0.31	1.5	1.654935	-46.3733	-22.94	0.036914	0.004724	0.020819
231	-0.09333	-0.08888	-0.14	-0.13333	1.5	1.512407	-10.36	-9.86666	0.038892	0.004532	0.021712
232	-0.10714	0.044642	-0.10714	0.044642	1	1.006719	-11.8928	4.955357	0.032225	0.006129	0.019177
233	-0.08035	0.080357	-0.08035	0.080357	1	1.006436	-8.91964	8.919642	0.029975	0.010705	0.020340
234	-0.05357	0.107142	-0.05357	0.107142	1	1.007149	-5.94642	11.89285	0.002102	0.000511	0.001307
235	-0.13392	0.151785	-0.13392	0.151785	1	1.020282	-14.8660	16.84821	0.025928	0.002281	0.014104
236	-0.00892	0.142857	-0.00892	0.142857	1	1.010192	-0.99107	15.85714	0.006763	0.000948	0.003856
237	-0.00446	0.174107	-0.00446	0.174107	1	1.015053	-0.49553	19.32589	0.025345	0.005233	0.015289
238	0.002232	0.035714	0.002232	0.035714	1	1.000640	0.247767	3.964285	0.043295	0.012748	0.028021
239	0.040178	0.053571	0.040178	0.053571	1	1.002239	4.459821	5.946428	0.031413	0.003266	0.017340
240	0.053571	0.167410	0.053571	0.167410	1	1.015330	5.946428	18.58258	0.103183	0.010266	0.056724
241	0.075892	-0.08482	0.075892	-0.08482	1	1.006456	8.424107	-9.41517	0.008642	0.001956	0.005299
242	0.084821	0.118303	0.084821	0.118303	1	1.010539	9.415178	13.13169	0.151217	0.032863	0.092040
243	0.107142	-0.10267	0.107142	-0.10267	1	1.010951	11.89285	-11.3973	0.057042	0.008820	0.032931
244	0.107142	-0.125	0.107142	-0.125	1	1.013461	11.89285	-13.875	0.019920	0.005594	0.012757
245	0.129464	-0.07589	0.129464	-0.07589	1	1.011197	14.37053	-8.42410	0.048943	0.008187	0.028565
246	0.142857	-0.05357	0.142857	-0.05357	1	1.011572	15.85714	-5.94642	0.075624	0.014532	0.045078
247	0.125	0.160714	0.125	0.160714	1	1.020516	13.875	17.83928	0.041053	0.004464	0.022759
248	0.174107	-0.06026	0.174107	-0.06026	1	1.016831	19.32589	-6.68973	0.045755	0.008940	0.027348
249	0.196428	-0.15178	0.196428	-0.15178	1	1.030350	21.80357	-16.8482	0.026560	0.002649	0.014605
250	0.178571	0.035714	0.178571	0.035714	1	1.016446	19.82142	3.964285	0.013527	0.002489	0.008008
251	0.1875	0.120535	0.1875	0.120535	1	1.024541	20.8125	13.37946	0.025928	0.002718	0.014323
252	0.205357	0.09375	0.205357	0.09375	1	1.025163	22.79464	10.40625	0.089167	0.018604	0.053886
253	0.200892	-0.14285	0.200892	-0.14285	1	1.029934	22.29910	-15.8571	0.028421	0.003983	0.016202
254	0.196428	-0.20535	0.196428	-0.20535	1	1.039594	21.80357	-22.7946	0.021022	0.005083	0.013053
255	0.200892	0.125	0.200892	0.125	1	1.027610	22.29910	13.875	0.054906	0.010803	0.032855
256	0.223214	-0.08035	0.223214	-0.08035	1	1.027755	24.77678	-8.91964	0.120751	0.021096	0.070923
257	0.232142	-0.12053	0.232142	-0.12053	1	1.033648	25.76785	-13.3794	0.037812	0.008534	0.023173
258	0.214285	0.073660	0.214285	0.073660	1	1.025350	23.78571	8.176339	0.050560	0.009913	0.030236
259	0.241071	0.017857	0.241071	0.017857	1	1.028802	26.75892	1.982142	0.039640	0.011645	0.025643
260	0.245535	-0.03571	0.245535	-0.03571	1	1.030321	27.25446	-3.96428	0.038892	0.007307	0.023099
261	0.232142	-0.12053	0.232142	-0.12053	1	1.033643	25.76785	-13.3794	0.040443	0.010112	0.025277
262	0.196429	0.133928	0.196428	0.133928	1	1.029872	21.80357	14.86607	0.100791	0.010121	0.055456

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Locations (1-8) X1	Y1		VEL. (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
211	15.79012	1529.509	465.9566	997.7328	0.020493	-99	-1	0	0	0.00E+00	0.00E+00	0.00E+00
212	10.17969	2117.192	662.3841	1389.788	0.002854	-99	-99	0	0	0.00E+00	0.00E+00	2.85E-03
213	16.07470	1384.723	555.1545	969.9389	0.017265	1	1	1	969.9389	0.00E+00	0.00E+00	0.00E+00
214	18.98839	1329.977	322.1271	826.0524	0.052031	1	-1	5	826.0524	0.00E+00	0.00E+00	0.00E+00
215	29.81061	909.3952	313.7883	611.5918	0.048572	1	-99	0	0	4.96E-02	0.00E+00	0.00E+00
216	13.10610	1670.936	565.6944	1118.315	0.010719	1	-99	0	0	0.00E+00	1.07E-02	0.00E+00
217	5.694210	3430.744	737.8908	2084.317	0.005708	-99	-1	0	0	0.00E+00	0.00E+00	0.00E+00
218	13.46432	1725.034	484.5841	1104.809	0.013615	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
219	7.873633	2561.536	694.8834	1628.209	0.002229	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
220	9.967916	2189.395	487.5291	1338.462	0.008247	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
221	5.943623	3255.354	679.4598	1967.407	0.002693	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
222	5.365306	3526.758	637.5800	2082.169	0.004276	1	1	1	2082.169	0.00E+00	0.00E+00	0.00E+00
223	8.846944	2283.023	661.1317	1472.077	0.004031	1	1	1	1472.077	0.00E+00	0.00E+00	0.00E+00
224	13.74506	1659.396	419.3920	1039.394	0.014944	1	1	1	1039.394	0.00E+00	0.00E+00	0.00E+00
225	11.99176	1800.034	539.7824	1169.908	0.009611	1	1	1	1169.908	0.00E+00	0.00E+00	0.00E+00
226	9.345323	2113.971	720.5467	1417.259	0.007762	1	-1	5	1417.259	0.00E+00	0.00E+00	0.00E+00
227	12.60288	1788.085	414.7008	1101.393	0.006032	2	-1	6	1101.393	0.00E+00	0.00E+00	0.00E+00
228	6.222851	3170.213	451.0944	1810.654	0.014876	2	-1	6	1810.654	0.00E+00	0.00E+00	0.00E+00
229	7.534213	2547.049	745.8139	1646.434	0.002254	2	1	2	1646.434	0.00E+00	0.00E+00	0.00E+00
230	13.44885	1834.589	392.5565	1113.573	0.021347	-99	-99	0	0	2.13E-02	0.00E+00	0.00E+00
231	11.51403	1941.405	387.2584	1164.332	0.019929	2	1	6	1164.332	0.00E+00	0.00E+00	1.99E-02
232	15.12194	1111.598	320.1737	715.8963	0.014213	2	1	2	715.8963	0.00E+00	0.00E+00	0.00E+00
233	38.83865	496.4337	229.3496	362.8946	0.019628	2	1	2	362.8946	0.00E+00	0.00E+00	0.00E+00
234	7.651020	1793.747	621.6269	1207.686	0.000826	2	1	2	1207.686	0.00E+00	0.00E+00	0.00E+00
235	7.089858	2119.783	342.4258	1231.104	0.008428	2	99	0	0	0.00E+00	0.00E+00	0.00E+00
236	5.186399	2568.024	588.5213	1578.273	0.002161	2	99	0	0	0.00E+00	0.00E+00	0.00E+00
237	18.96705	934.1492	286.1546	610.1519	0.012114	2	99	0	0	0.00E+00	0.00E+00	0.00E+00
238	21.05514	810.6271	324.0213	567.3242	0.022916	3	1	3	567.3242	0.00E+00	0.00E+00	0.00E+00
239	12.11072	1384.580	253.5673	819.0740	0.011776	3	1	3	819.0740	0.00E+00	0.00E+00	0.00E+00
240	22.91763	869.2169	153.9822	511.5995	0.045534	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
241	7.547460	1830.043	600.6763	1215.360	0.003329	3	-1	7	1215.360	0.00E+00	0.00E+00	3.33E-03
242	30.20405	652.3867	207.6527	430.0197	0.081847	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
243	20.04158	923.5447	227.7443	575.6445	0.026011	3	-1	7	575.6445	0.00E+00	0.00E+00	2.60E-02
244	16.46117	992.1726	382.7458	687.4592	[illegible]	3	-99	0	0	0.00E+00	9.88E-03	0.00E+00
245	19.60405	931.4867	243.6606	587.5737	0.022527	3	-1	7	587.5737	0.00E+00	0.00E+00	0.00E+00
246	23.29276	805.8029	233.9038	519.8434	0.037374	3	-1	7	519.8434	0.00E+00	0.00E+00	0.00E+00
247	8.343343	1644.184	350.2161	1099.700	0.014305	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
248	18.28271	968.1988	284.5521	626.3754	0.021442	4	-1	8	626.3754	0.00E+00	0.00E+00	0.00E+00
249	9.585683	1689.441	299.8314	994.6914	0.009533	4	-99	0	0	0.00E+00	9.53E-03	0.00E+00
250	9.989459	1534.041	430.9734	982.5074	0.005381	4	1	4	982.5074	0.00E+00	0.00E+00	0.00E+00
251	9.076148	1746.589	321.7970	1034.193	0.054204	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
252	34.88820	595.0509	183.7046	389.3778	0.050118	4	1	4	389.3778	0.00E+00	0.00E+00	0.00E+00
253	11.72661	1413.178	323.7136	868.4490	0.011247	4	-99	0	0	0.00E+00	1.13E-02	0.00E+00
254	15.32164	1092.235	376.6544	734.4473	0.010056	4	-99	0	0	1.01E-02	0.00E+00	0.00E+00
255	18.26198	975.8864	288.3033	632.0952	0.025465	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
256	22.98237	832.9474	225.0807	529.0180	0.059037	4	-1	8	529.0180	0.00E+00	0.00E+00	5.90E-02
257	15.10366	1110.122	363.5191	736.8207	0.017656	4	-99	0	0	0.00E+00	1.77E-02	0.00E+00
258	8.598767	1714.752	505.2704	1110.011	0.019759	4	1	4	1110.011	0.00E+00	0.00E+00	0.00E+00
259	20.66840	839.5877	335.0338	587.3107	0.021311	4	1	4	587.3107	0.00E+00	0.00E+00	0.00E+00
260	11.56323	1374.125	412.1047	893.1153	0.016509	4	-1	8	893.1153	0.00E+00	0.00E+00	0.00E+00
261	10.2843	1459.293	515.9382	987.6160	0.017580	4	-99	0	0	0.00E+00	1.76E-02	0.00E+00
262	16.58952	1117.127	199.2383	658.2079	0.041459	4	99	0	0	0.00E+00	0.00E+00	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
211	2.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
213	0.00E+00	1.73E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
214	5.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
215	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
217	0.00E+00	5.71E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
218	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-02
219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-03	0.00E+00
220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.25E-03	0.00E+00
221	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-03
222	0.00E+00	0.00E+00	0.00E+00	4.28E-03	0.00E+00	0.00E+00
223	0.00E+00	0.00E+00	0.00E+00	4.03E-03	0.00E+00	0.00E+00
224	0.00E+00	1.49E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
225	0.00E+00	0.00E+00	9.61E-03	0.00E+00	0.00E+00	0.00E+00
226	7.76E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
227	6.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
228	0.00E+00	1.49E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
229	0.00E+00	0.00E+00	0.00E+00	2.25E-03	0.00E+00	0.00E+00
230	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
232	0.00E+00	0.00E+00	1.42E-02	0.00E+00	0.00E+00	0.00E+00
233	0.00E+00	0.00E+00	0.00E+00	1.96E-02	0.00E+00	0.00E+00
234	0.00E+00	0.00E+00	0.00E+00	8.27E-04	0.00E+00	0.00E+00
235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.43E-03	0.00E+00
236	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-03	0.00E+00
237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-02
238	0.00E+00	0.00E+00	2.29E-02	0.00E+00	0.00E+00	0.00E+00
239	0.00E+00	0.00E+00	1.18E-02	0.00E+00	0.00E+00	0.00E+00
240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.55E-02
241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
242	0.00E+00	0.00E+00	0.00E+00	8.18E-02	0.00E+00	0.00E+00
243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
245	2.25E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
246	3.74E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
247	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-02	0.00E+00
248	2.14E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
249	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
250	0.00E+00	0.00E+00	5.38E-03	0.00E+00	0.00E+00	0.00E+00
251	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.20E-03	0.00E+00
252	0.00E+00	0.00E+00	0.00E+00	5.01E-02	0.00E+00	0.00E+00
253	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
254	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
255	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-02	0.00E+00
256	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
257	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
258	0.00E+00	0.00E+00	1.98E-02	0.00E+00	0.00E+00	0.00E+00
259	0.00E+00	2.13E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
260	1.65E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
261	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
262	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.15E-02	0.00E+00

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	SHEET No.	SHEET POSITION X (in)	SHEET POSITION Y (in)	MASS (grams)	LEN (in)	WID (in)	THIC (in)	L/D	POSITION COORDINATES, X (in)	POSITION COORDINATES, Y (in)	POSITION COORDINATES, Z (in)	PATH R (in)
263	2	69.5	44.25	0.76	0.563	0.265	0.083	2.124528	21.5	20.25	112	115.8288
264	2	81	12	0.39	0.412	0.197	0.092	2.091370	33	-12	112	117.3754
265	2	75	43.5	0.14	0.152	0.106	0.034	1.433962	27	19.5	112	116.8471
266	2	81	15	0.2	0.245	0.209	0.029	1.172248	33	-9	112	117.1067
267	2	79	44.5	0.15	0.202	0.145	0.04	1.393103	31	20.5	112	118.0052
268	2	82.5	40	1.12	0.469	0.461	0.086	1.017353	34.5	16	112	118.2803
269	2	91	25.5	0.3	0.286	0.227	0.082	1.259911	43	1.5	112	119.9802
270	18	77	77.25	11.7	1.465	0.786	0.224	1.863867	29	53.25	120	134.4491
271	14	85.5	6	2.5	0.711	0.361	0.204	1.969529	37.5	-18	118	125.1169
272	10	18.25	6	2.18	0.736	0.428	0.142	1.719626	-29.75	-18	116	121.0993
273	10	43	19	1.6	0.579	0.342	0.125	1.692982	-5	-5	116	116.2153
274	9	53	45	1.96	0.946	0.241	0.121	3.925311	5	21	115.5	117.5
275	8	38.5	6	1.41	0.751	0.31	0.106	2.422580	-9.5	-18	115	116.7871
276	7	16.5	12	0.61	0.473	0.241	0.125	1.962655	31.5	-12	114.5	119.3587
277	6	22	39.5	3.69	1.307	0.423	0.129	3.089834	-26	15.5	114	117.9502
278	5	51.25	41.25	0.69	0.582	0.3	0.066	1.94	3.25	17.25	114	115.3435
279	4	59	5.5	1.2	0.574	0.312	0.156	1.839743	11	-18.5	113	115.0315
280	4	56	14.5	0.71	0.559	0.295	0.155	1.894915	8	-9.5	113	113.6804
281	4	59	8	2.3	0.852	0.348	0.199	2.448275	11	-16	113	114.6564
282	4	79.5	8	0.36	0.381	0.276	0.061	1.380434	31.5	-16	113	116.3944
283	4	52	4	4.29	1.21	0.616	0.135	1.964285	4	-20	113	114.8259
284	3	19	16	1.16	0.595	0.437	0.144	1.361556	-29	-8	112.5	116.4527

Total Mass: 387.52 grams
Total Impulse Over Target at 9 ft. (4.8 Sheet): 36.687 lb-sec
Average Specific Impulse (at center): 10.492 psi-ms
(based on curved target surface calculation)

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	TAN X	TAN Y	PENETRATION X'(in)	PENETRATION Y'(in)	COORDINATE Z'(in)	DEPTH R'(in)	Xo	Yo	PRESENTED AREA (IN²) MAX.	PRESENTED AREA (IN²) MIN.	PRESENTED AREA (IN²) AVG.
263	0.191964	0.180803	0.191964	0.180803	1	1.034185	21.30303	20.06919	0.071224	0.019500	0.040862
264	0.294642	-0.10714	0.294642	-0.10714	1	1.047995	32.70535	-11.8928	0.032973	0.007363	0.020168
265	0.241071	0.174107	0.241071	0.174107	1	1.043277	26.75892	19.32589	0.032028	0.007164	0.019596
266	0.294642	-0.08035	0.294642	-0.08035	1	1.045596	32.70535	-8.91964	0.053644	0.006349	0.029997
267	0.276785	0.183035	0.276785	0.183035	1	1.053618	30.72321	20.31696	0.029169	0.005776	0.017472
268	0.308035	0.142857	0.308035	0.142857	1	1.056074	34.19196	15.85714	0.101300	0.018575	0.059938
269	0.383928	0.013392	0.383928	0.013392	1	1.071251	42.61607	1.486607	0.028457	0.008159	0.018308
270	0.241666	0.44375	2.175	3.99375	9	10.08368	26.825	49.25625	0.406286	0.062121	0.234203
271	0.317796	-0.15254	2.224576	-1.06779	7	7.422191	35.27542	-16.9322	0.095324	0.027450	0.061387
272	-0.25646	-0.15517	-1.28232	-0.77586	5	5.219801	-28.4676	-17.2241	0.119415	0.023039	0.071227
273	-0.04310	-0.04310	-0.21551	-0.21551	5	5.009280	-4.78448	-4.78448	0.099564	0.021494	0.060529
274	0.043290	0.181818	0.194805	0.818181	4.5	4.577922	4.805194	20.18181	0.125993	0.016116	0.071057
275	-0.08260	-0.15652	-0.33043	-0.62608	4	4.062163	-9.16956	-17.3739	0.103468	0.014604	0.059036
276	-0.27510	-0.10480	-0.96288	-0.36681	3.5	3.648519	-30.5371	-11.6331	0.037958	0.010031	0.023995
277	-0.22807	0.135964	-0.68421	0.407894	3	3.103952	-25.3157	15.09210	0.222500	0.021960	0.122230
278	0.028503	0.151315	0.085526	0.453947	3	3.035355	3.164473	16.79605	0.062403	0.009221	0.035815
279	0.097345	-0.16371	0.194690	-0.32743	2	2.035956	10.80530	-18.1725	0.059834	0.016261	0.038047
280	0.070796	-0.08407	0.141592	-0.16814	2	2.012043	7.858407	-9.33185	0.035630	0.009879	0.022755
281	0.097345	-0.14159	0.194690	-0.28318	2	2.029309	10.80530	-15.7168	0.089901	0.020948	0.055450
282	0.278761	-0.14159	0.557522	-0.28318	2	2.095477	30.94247	-15.7168	0.045905	0.007349	0.026627
283	0.035398	-0.17699	0.070796	-0.35398	2	2.032817	3.929203	-19.6460	0.247182	0.027578	0.137380
284	-0.25777	-0.07111	-0.38666	-0.10666	1.5	1.552703	-28.6133	-7.89333	0.062659	0.015164	0.038912

Total

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	AVG AREAL D(gr/in2)	THOR V (ft/sec) (max)	THOR V (ft/sec) (min)	THOR V (ft/sec) (avg)	MV lb-sec	Vel. Screen Locations X1	Y1	(1-8)	VEL. (fps)	MV lb-sec -11+-7.5	MV lb-sec -7.5+-5	MV lb-sec -5+-2.5
263	18.59901	998.2342	237.4978	617.8660	0.032149	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
264	19.33705	933.2983	303.1717	618.2353	0.016507	4	-1	8	618.2353	0.00E+00	0.00E+00	1.65E-02
265	7.144065	1962.379	638.2773	1300.328	0.012463	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
266	6.667290	2214.709	446.9311	1330.820	0.018223	4	-1	8	1330.820	0.00E+00	0.00E+00	1.82E-02
267	8.584833	1750.087	519.5067	1134.797	0.011654	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
268	18.68590	987.3913	276.6836	632.0375	0.048465	4	99	0	0	0.00E+00	0.00E+00	0.00E+00
269	16.38581	1034.309	405.2623	719.7858	0.014784	99	1	0	0	0.00E+00	0.00E+00	0.00E+00
270	49.95648	2615.896	639.6292	1627.762	1.303911	4	0	0	0	0.00E+00	0.00E+00	0.00E+00
271	40.75815	2229.813	874.1562	1551.985	0.265649	4	-99	0	0	0.00E+00	2.66E-01	0.00E+00
272	30.60606	2247.063	654.1453	1450.607	0.216509	1	-99	0	0	0.00E+00	2.17E-01	0.00E+00
273	26.43332	2397.403	759.3023	1578.353	0.172900	2	-1	6	1578.353	0.00E+00	0.00E+00	0.00E+00
274	27.58340	2296.171	491.1058	1393.638	0.187015	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
275	23.88365	2318.359	533.8635	1426.111	0.137671	2	-99	0	0	0.00E+00	1.38E-01	0.00E+00
276	25.42177	1890.153	696.6806	1293.417	0.054018	1	-1	5	1293.417	0.00E+00	0.00E+00	5.40E-02
277	30.18886	1635.257	287.9531	961.6053	0.242937	1	99	0	0	0.00E+00	0.00E+00	0.00E+00
278	19.26552	2179.593	519.4659	1349.529	0.063753	3	99	0	0	0.00E+00	0.00E+00	0.00E+00
279	31.53911	1033.534	389.0312	711.2829	0.058437	3	-99	0	0	5.84E-02	0.00E+00	0.00E+00
280	31.20190	1029.369	393.3338	711.3518	0.034579	3	-1	7	711.3518	0.00E+00	0.00E+00	3.46E-02
281	41.47876	858.9415	288.5849	573.7632	0.090350	3	-99	0	0	0.00E+00	9.04E-02	0.00E+00
282	13.51974	2135.782	540.5808	1338.181	0.032982	4	-99	0	0	0.00E+00	3.30E-02	0.00E+00
283	31.22717	1150.364	222.0735	686.2190	0.201553	3	-99	0	0	2.02E-01	0.00E+00	0.00E+00
284	29.61061	895.6466	309.0443	602.3455	0.047838	1	-1	5	602.3455	0.00E+00	0.00E+00	0.00E+00
-----										4.665	7.948	7.523
Total												

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

FRAG NUM	MV lb-sec -2.5-0	MV lb-sec Chg. Ht.	MV lb-sec 0+2.5	MV lb-sec 2.5+5	MV lb-sec 5+7.5	MV lb-sec 7.5+11
263	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E-02
264	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
265	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02
266	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
267	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-02
268	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.85E-02	0.00E+00
269	0.00E+00	1.48E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
270	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E+00
271	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
272	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
273	1.73E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
274	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-01
275	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
276	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
277	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-01	0.00E+00
278	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.38E-02	0.00E+00
279	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
280	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
281	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
282	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
283	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
284	4.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
----- Total	5.706	5.545	2.098	0.777	0.734	1.696

(The reverse side of this page is blank.)

APPENDIX G

Calculations of Horizontal Blast Impulse Distributions and Blast and Fragment Impulse Distributions

TABLE G-1. CALCULATIONS OF HORIZONTAL BLAST IMPULSE DISTRIBUTIONS AND BLAST AND FRAGMENT IMPULSE DISTRIBUTIONS.

r	2.373 Lb. Chg. at 6 in.				2.373 Lb. Chg. at 12 in.				2.373 Lb. Chg. at 18 in.			
(in)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)
0.00	3381.00	3401.00	8.30	8.30	991.20	999.82	2.52	2.52	516.40	521.44	1.32	1.32
0.90	3242.00	3261.96	22.10	30.40	981.40	990.00	7.34	9.86	514.30	519.33	3.91	5.24
1.80	2875.00	2894.85	30.68	61.08	952.80	961.36	11.66	21.52	507.80	512.80	6.39	11.63
2.70	2392.00	2411.67	34.24	95.33	908.20	916.68	15.31	36.83	497.30	502.26	8.70	20.32
3.60	1903.00	1922.43	34.20	129.52	851.10	859.47	18.19	55.02	483.30	488.20	10.79	31.11
4.50	1474.00	1493.13	32.10	161.63	785.90	794.15	20.28	75.30	466.20	471.02	12.63	43.74
5.40	1128.00	1146.79	29.13	190.76	716.50	724.60	21.65	96.95	446.60	451.34	14.22	57.96
6.30	862.20	880.62	25.97	216.73	646.60	654.54	22.39	119.34	425.20	429.84	15.54	73.50
7.20	662.40	680.41	23.00	239.73	578.80	586.56	22.62	141.96	402.60	407.14	16.60	90.10
8.10	514.10	531.69	20.36	260.09	515.20	522.78	22.44	164.40	379.30	383.73	17.42	107.52
9.00	404.00	421.16	18.10	278.19	456.80	464.20	21.98	186.38	355.90	360.22	18.01	125.53
9.90	322.00	338.72	16.19	294.39	404.10	411.31	21.32	207.70	332.80	337.01	18.41	143.94
10.80	260.40	276.68	14.60	308.98	357.20	364.22	20.53	228.23	310.40	314.50	18.63	162.56
11.70	213.60	229.45	13.28	322.26	315.90	322.73	19.69	247.92	288.80	292.79	18.71	181.27
12.60	177.80	193.22	12.18	334.44	279.90	286.55	18.82	266.73	268.40	272.29	18.67	199.94
13.50	150.10	165.11	11.29	345.73	248.50	254.97	17.96	284.70	249.20	252.98	18.53	218.47
14.40	128.50	143.10	10.55	356.28	221.40	227.69	17.13	301.83	231.20	234.88	18.32	236.79
15.30	111.40	125.61	9.95	366.23	197.90	204.02	16.36	318.19	214.60	218.18	18.06	254.85
16.20	97.87	111.70	9.46	375.69	177.70	183.66	15.63	333.82	199.30	202.78	17.76	272.61
17.10	86.99	100.45	9.06	384.75	160.20	166.00	14.96	348.78	185.20	188.59	17.44	290.05
18.00	78.22	91.32	8.75	393.50	145.10	150.75	14.37	363.14	172.40	175.70	17.10	307.15
18.90	71.09	83.85	8.50	402.00	132.20	137.70	13.83	376.97	160.70	163.92	16.77	323.92
19.80	65.28	77.72	8.32	410.32	121.00	126.36	13.34	390.31	150.10	153.23	16.44	340.35
20.70	60.52	72.64	8.19	418.51	111.30	116.52	12.92	403.23	140.50	143.55	16.12	356.47
21.60	56.62	68.44	8.10	426.60	102.90	107.99	12.55	415.78	131.80	134.78	15.81	372.28
22.50	53.41	64.94	8.05	434.65	95.69	100.66	12.24	428.02	123.90	126.81	15.54	387.82
23.40	50.77	62.02	8.04	442.69	89.45	94.30	11.97	439.99	116.90	119.74	15.29	403.11
24.30	48.62	59.60	8.06	450.75	84.04	88.77	11.76	451.75	110.60	113.37	15.06	418.17
25.20	46.86	57.59	8.11	458.86	79.38	84.00	11.58	463.33	104.90	107.60	14.86	433.03
26.10	45.43	55.91	8.19	467.05	75.34	79.86	11.45	474.78	99.79	102.43	14.69	447.72
27.00	44.30	54.55	8.29	475.34	71.87	76.29	11.36	486.15	95.24	97.82	14.55	462.26
27.90	43.40	53.42	8.42	483.76	68.88	73.20	11.31	497.45	91.19	93.71	14.44	476.70
28.80	42.72	52.52	8.57	492.33	66.31	70.53	11.29	508.74	87.58	90.05	14.35	491.06
29.70	42.22	51.81	8.74	501.07	64.12	68.25	11.30	520.05	84.37	86.79	14.31	505.36
30.60	41.87	51.26	8.93	510.00	62.26	66.31	11.35	531.40	81.54	83.91	14.28	519.65
31.50	41.67	50.86	9.14	519.14	60.68	64.64	11.43	542.83	79.04	81.36	14.29	533.94
32.40	41.59	50.60	9.37	528.51	59.37	63.25	11.53	554.36	76.84	79.11	14.33	548.27
33.30	41.62	50.45	9.62	538.13	58.29	62.09	11.67	566.03	74.93	77.15	14.40	562.67
34.20	41.75	50.41	9.89	548.02	57.42	61.15	11.83	577.86	73.26	75.44	14.49	577.16
35.10	41.97	50.46	10.17	558.19	56.73	60.39	12.02	589.89	71.83	73.97	14.62	591.78
36.00	42.27	50.60	56.29	614.48	56.21	59.80	66.53	656.41	70.61	72.71	80.89	672.67

Impulse over 6x6 = 614.48 lb-sec   Impulse over 6x6 = 656.41 lb-sec   Impulse over 6x6 = 672.67 lb-sec

TABLE G-1. CALCULATIONS OF HORIZONTAL BLAST IMPULSE DISTRIBUTIONS AND BLAST AND FRAGMENT IMPULSE DISTRIBUTIONS (CONTINUED).

r	0.5666 Lb. Chg. at 6 in.				0.5666 Lb. Chg. at 12 in.				0.5666 Lb. Chg. at 18 in.			
(in)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)	Chg. Only Impulse (psi-ms)	Chg+Frg Impulse (psi-ms)	Total Impulse (lb-sec)	Cumul. Total (lb-sec)
0.00	886.70	1806.40	4.59	4.59	286.70	659.84	1.67	1.67	157.10	365.64	0.93	0.93
0.90	851.70	1804.68	13.47	18.06	284.00	656.44	4.94	6.61	156.50	364.65	2.76	3.69
1.80	759.00	1764.59	21.17	39.23	276.20	646.58	8.03	14.64	154.70	361.70	4.54	8.23
2.70	636.50	1663.64	27.25	66.48	264.00	631.03	10.88	25.52	151.80	356.92	6.24	14.47
3.60	511.50	1530.01	31.87	98.35	248.30	610.81	13.45	38.97	147.90	350.50	7.85	22.32
4.50	401.00	1391.40	35.42	133.77	230.40	587.39	15.73	54.70	143.10	342.61	9.34	31.66
5.40	311.10	1265.22	38.31	172.07	211.30	561.93	17.72	72.42	137.70	333.66	10.71	42.37
6.30	241.40	1158.01	40.83	212.91	192.10	535.71	19.45	91.87	131.80	323.83	11.96	54.34
7.20	188.80	1069.77	43.16	256.07	173.50	509.59	20.94	112.81	125.60	313.43	13.09	67.43
8.10	149.40	997.79	45.38	301.45	155.90	484.12	22.24	135.05	119.20	302.64	14.10	81.53
9.00	120.10	938.50	47.51	348.96	139.80	459.95	23.37	158.42	112.80	291.73	15.01	96.54
9.90	98.19	889.08	49.58	398.53	125.30	437.29	24.37	182.79	106.50	280.86	15.82	112.36
10.80	81.72	847.05	51.57	450.10	112.50	416.33	25.25	208.04	100.50	270.30	16.54	128.90
11.70	69.27	810.63	53.49	503.60	101.20	396.93	26.05	234.09	94.67	259.95	17.18	146.08
12.60	59.80	778.56	55.34	558.94	91.39	379.16	26.78	260.87	89.23	250.06	17.76	163.84
13.50	52.56	749.91	57.11	616.05	82.93	362.92	27.46	288.33	84.17	240.65	18.28	182.12
14.40	46.99	723.99	58.81	674.86	75.68	348.09	28.09	316.42	79.51	231.75	18.76	200.88
15.30	42.71	700.30	60.43	735.29	69.49	334.55	28.70	345.12	75.25	223.39	19.20	220.08
16.20	39.43	678.49	61.98	797.27	64.25	322.20	29.27	374.39	71.40	215.56	19.61	239.69
17.10	36.92	658.30	63.47	860.73	59.83	310.92	29.83	404.23	67.95	208.28	20.00	259.69
18.00	35.02	639.50	64.89	925.62	56.11	300.59	30.38	434.60	64.88	201.51	20.33	280.02
18.90	33.61	621.93	66.25	991.87	53.02	291.14	30.91	465.51	61.82	194.90	20.63	300.65
19.80	32.60	605.46	67.56	1059.43	50.47	282.48	31.44	496.95	58.86	188.53	20.90	321.55
20.70	31.92	589.98	68.82	1128.25	48.38	274.52	31.96	528.91	56.11	182.49	21.14	342.69
21.60	31.50	575.41	70.03	1198.28	46.71	267.21	32.48	561.38	53.56	176.80	21.37	364.07
22.50	31.31	561.66	71.21	1269.49	45.38	260.48	32.91	594.29	51.18	171.39	21.58	385.64
23.40	31.30	548.67	72.34	1341.83	43.65	253.55	33.29	627.58	48.97	166.28	21.77	407.42
24.30	31.46	536.39	73.44	1415.28	41.89	246.81	33.64	661.22	46.90	161.43	21.95	429.37
25.20	31.76	524.76	74.52	1489.79	40.25	240.39	33.98	695.20	44.97	156.82	22.11	451.48
26.10	30.77	513.75	75.35	1565.15	38.71	234.26	34.29	729.49	43.17	152.46	22.26	473.74
27.00	30.05	501.89	76.17	1641.32	37.27	228.41	34.59	764.08	41.47	148.30	22.41	496.15
27.90	29.32	490.73	76.95	1718.27	35.91	222.82	34.86	798.95	39.89	144.35	22.54	518.69
28.80	28.56	479.97	77.67	1795.94	34.63	217.47	35.12	834.07	38.39	140.58	22.66	541.35
29.70	27.84	469.59	78.36	1874.30	33.42	212.35	35.37	869.44	36.99	136.99	22.77	564.12
30.60	27.11	459.58	79.00	1953.30	32.28	207.45	35.60	905.04	35.67	133.57	22.88	587.00
31.50	26.40	449.93	79.61	2032.91	31.20	202.75	35.82	940.85	34.43	130.30	22.98	609.98
32.40	25.70	440.64	80.19	2113.10	30.18	198.24	36.02	976.88	33.26	127.19	23.07	633.05
33.30	25.02	431.67	80.73	2193.83	29.21	193.92	36.22	1013.09	32.15	124.20	23.16	656.21
34.20	24.37	423.02	81.26	2275.09	28.29	189.77	36.40	1049.50	31.11	121.36	23.24	679.45
35.10	23.73	414.69	81.75	2356.83	27.42	185.78	36.58	1086.07	30.12	118.62	23.32	702.77
36.00	23.12	406.65	452.39	2809.23	26.60	181.96	202.43	1288.50	29.18	116.01	129.06	831.83

Impulse over 6x6 = 2809.23 lb-sec
Impulse over 3x3 = 1103.48 lb-sec

Impulse over 6x6 = 1288.50 lb-sec
Impulse over 3x3 = 518.20 lb-sec

Impulse over 6x6 = 831.83 lb-sec
Impulse over 3x3 = 336.07 lb-sec

(The reverse side of this page is blank.)

APPENDIX H

Severe Dynamic Environments (Krauthammer) Code Output

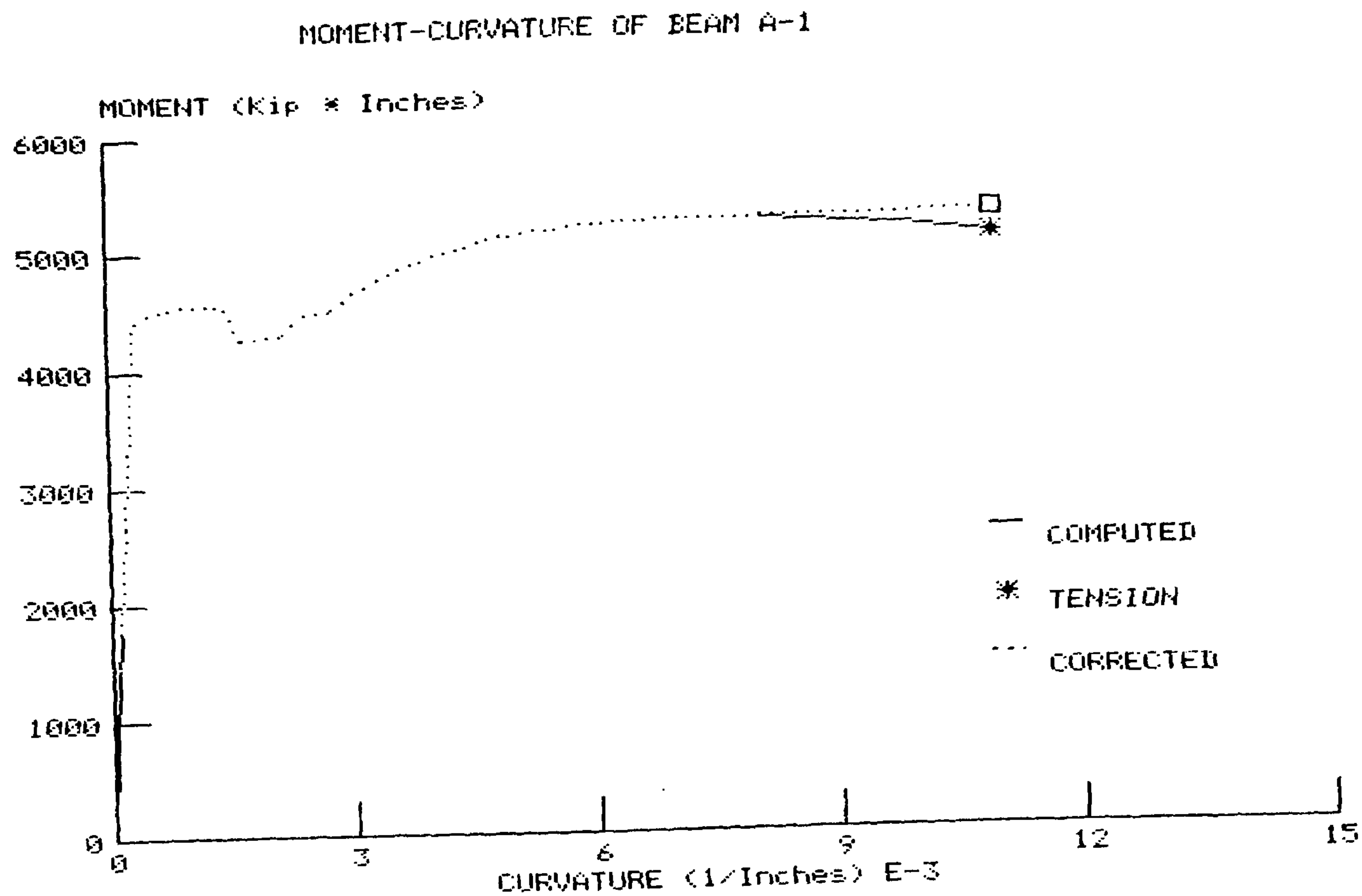


Figure H-1. Moment-Curvature of Beam A-1.

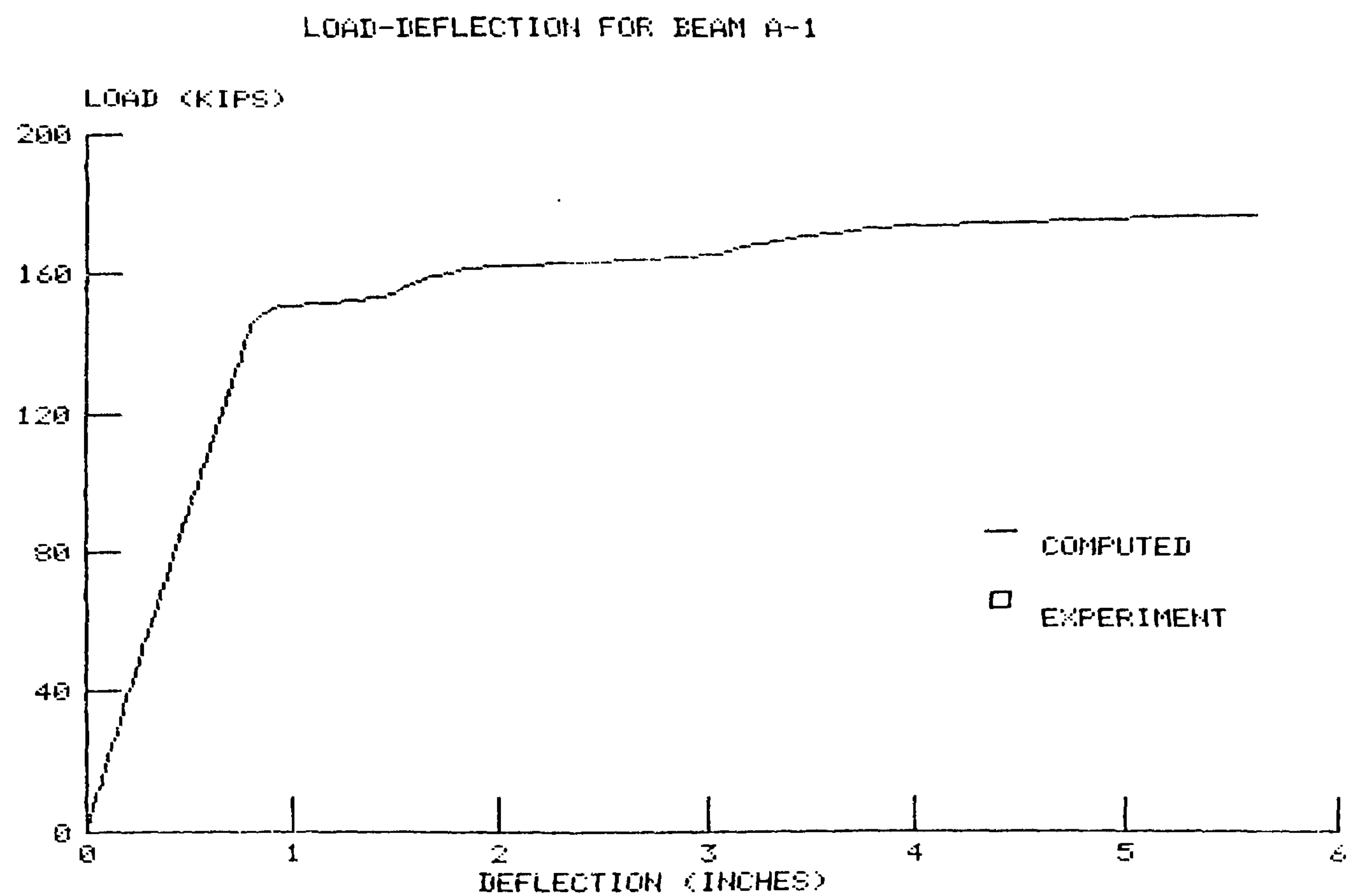


Figure H-2. Load Deflection for Beam A-1.

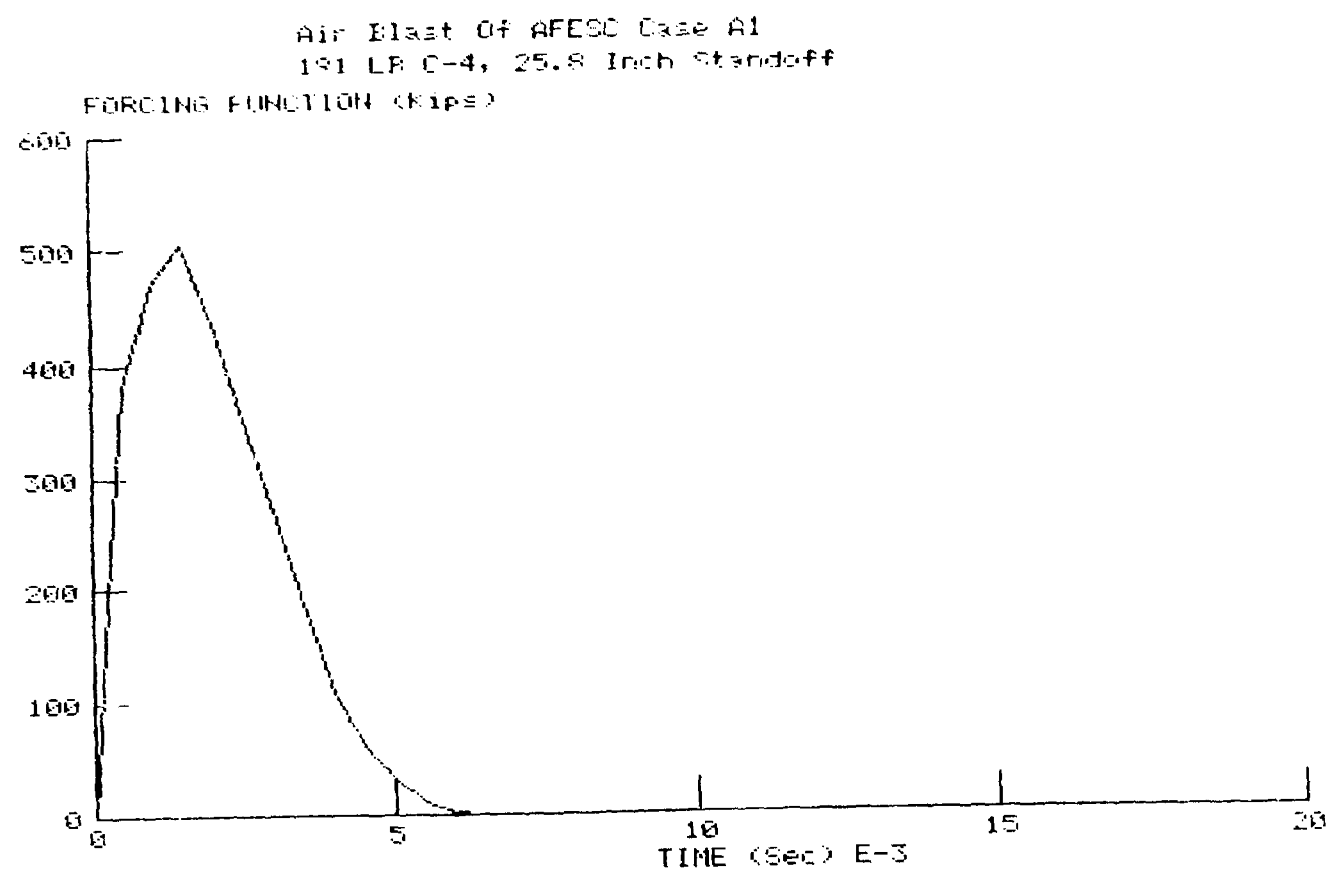


Figure H-3. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Forcing Function, Time.

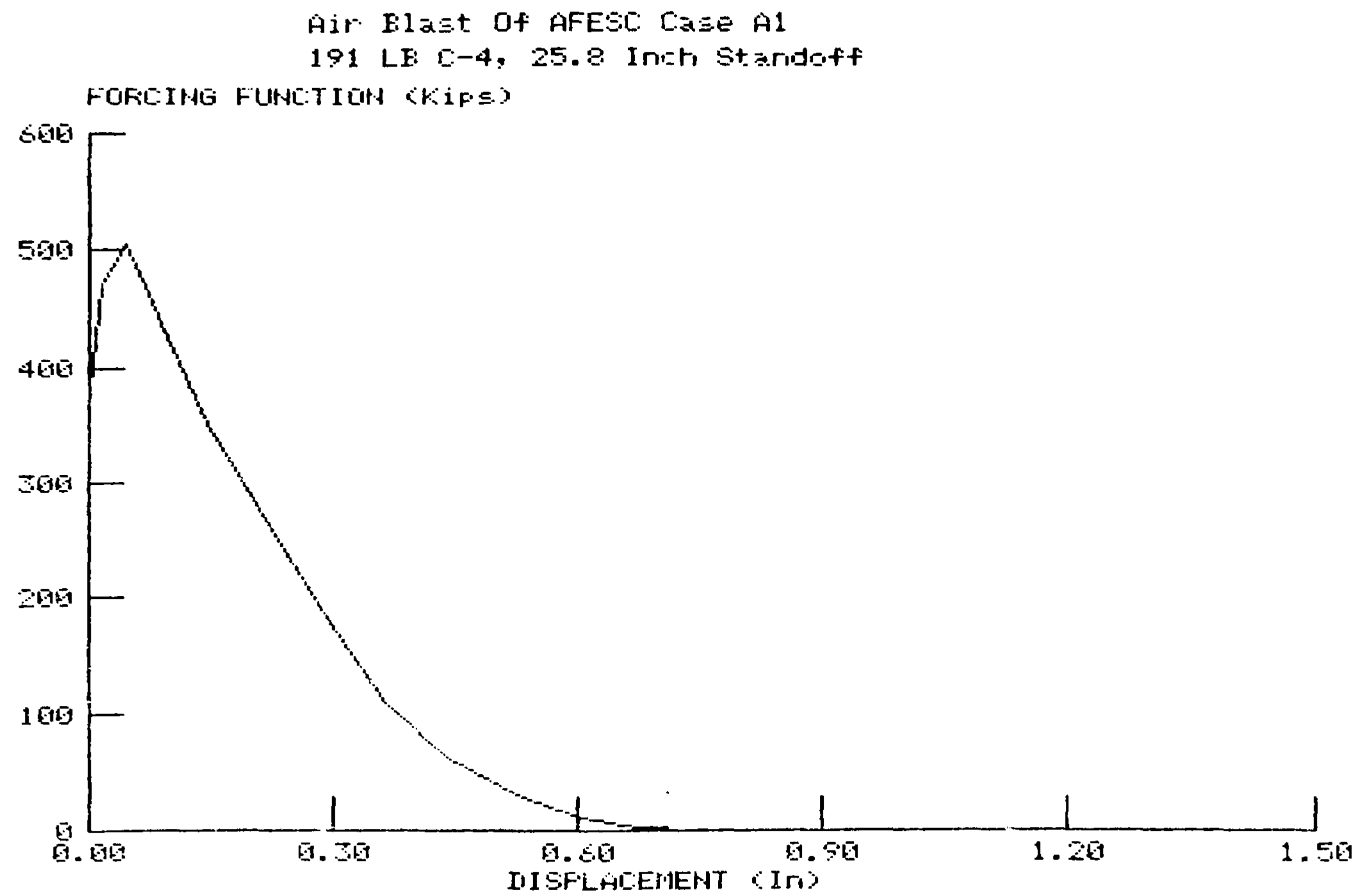


Figure H-4. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Forcing Function, Disp.

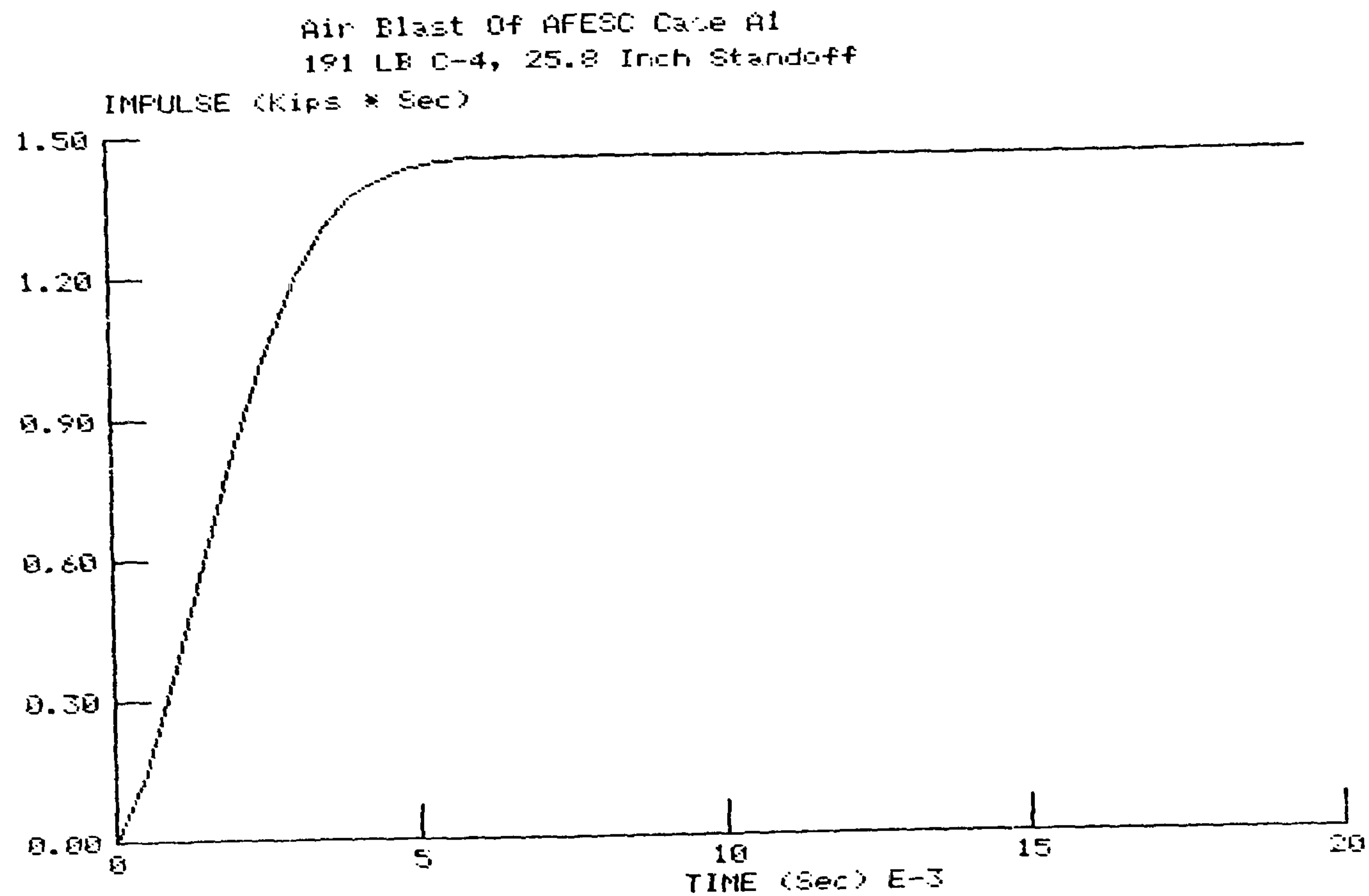


Figure H-5. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Impulse, Time.

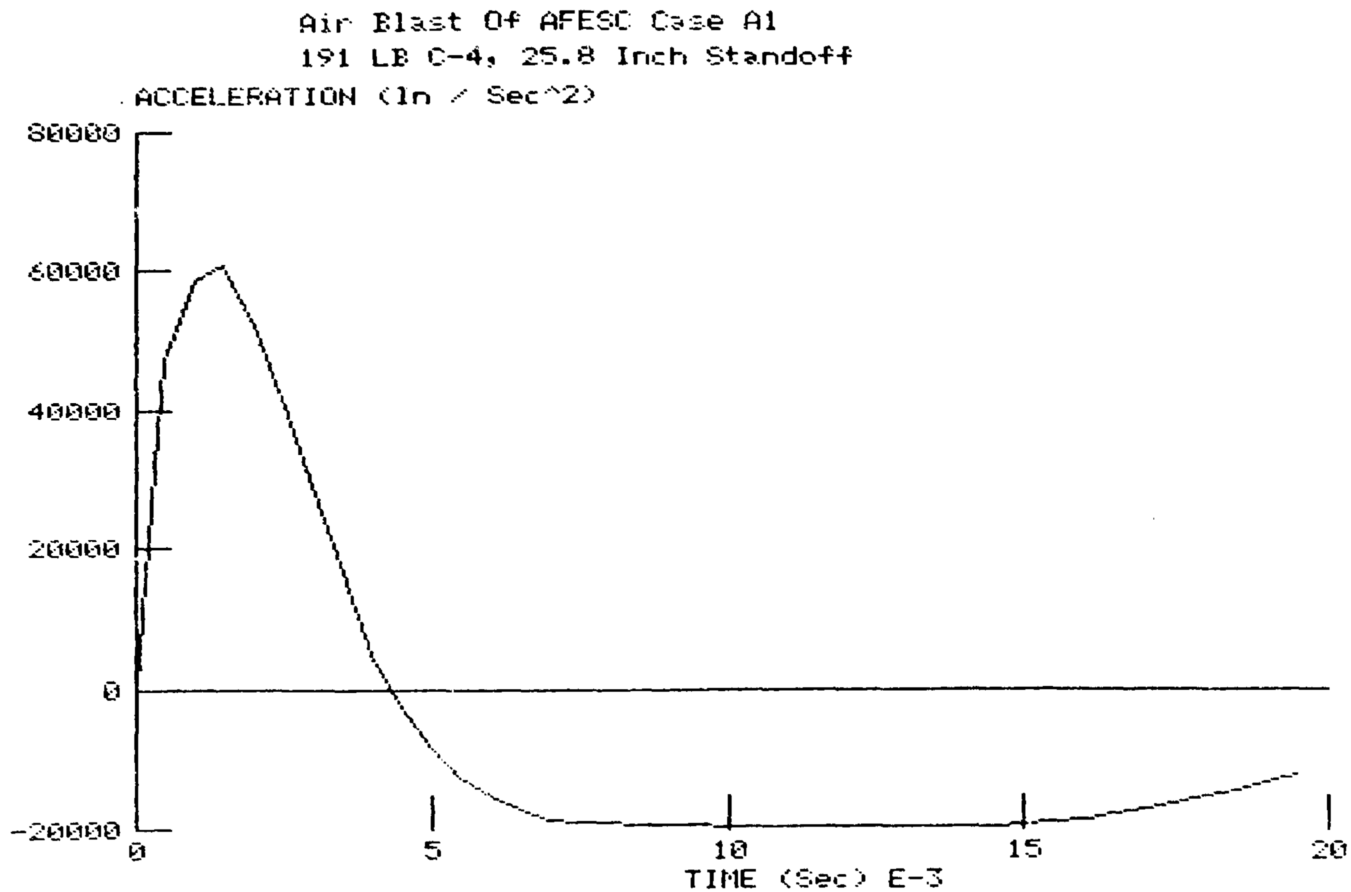


Figure H-6. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Acceleration, Time.

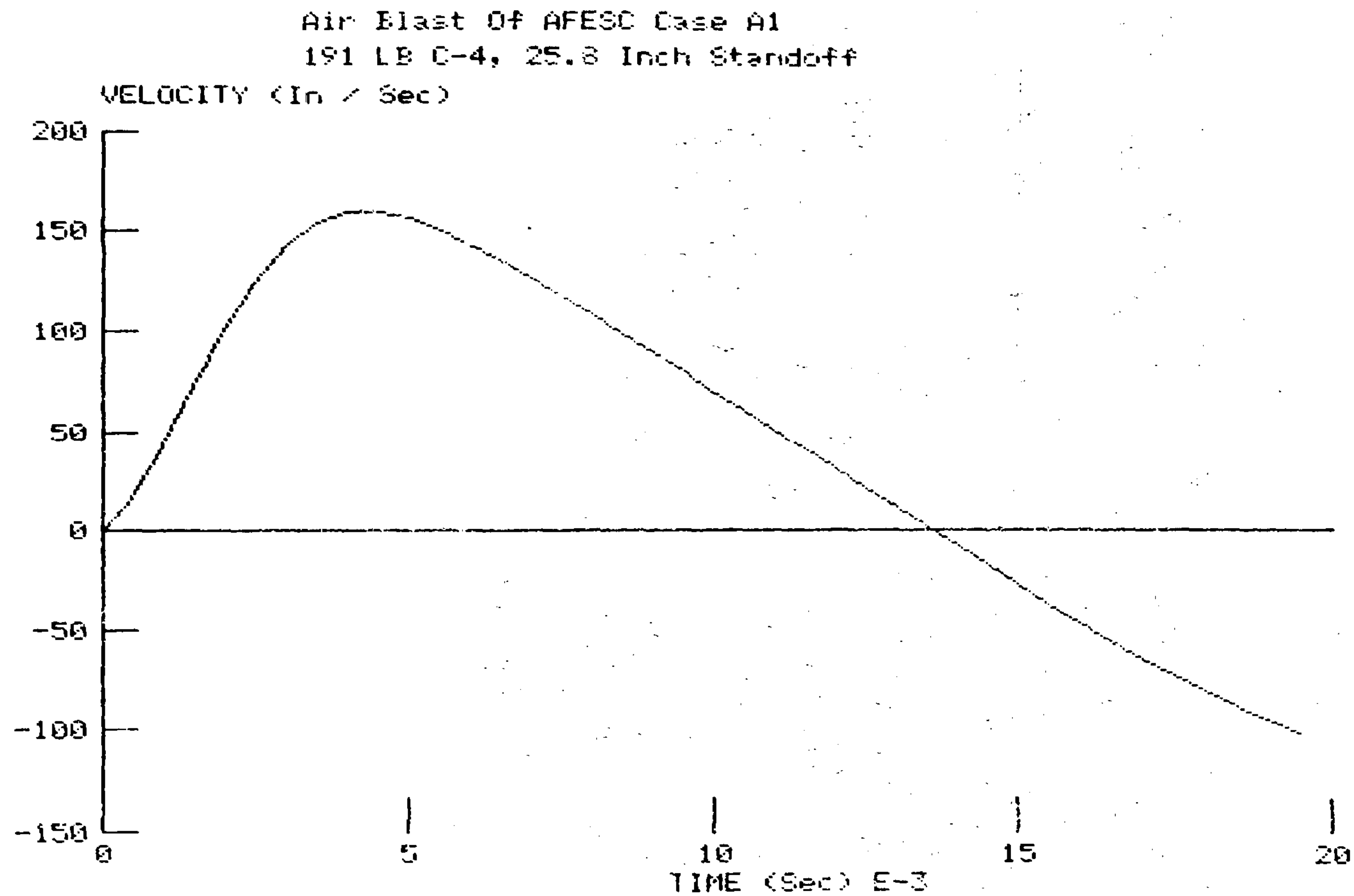


Figure H-7. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Velocity, Time.

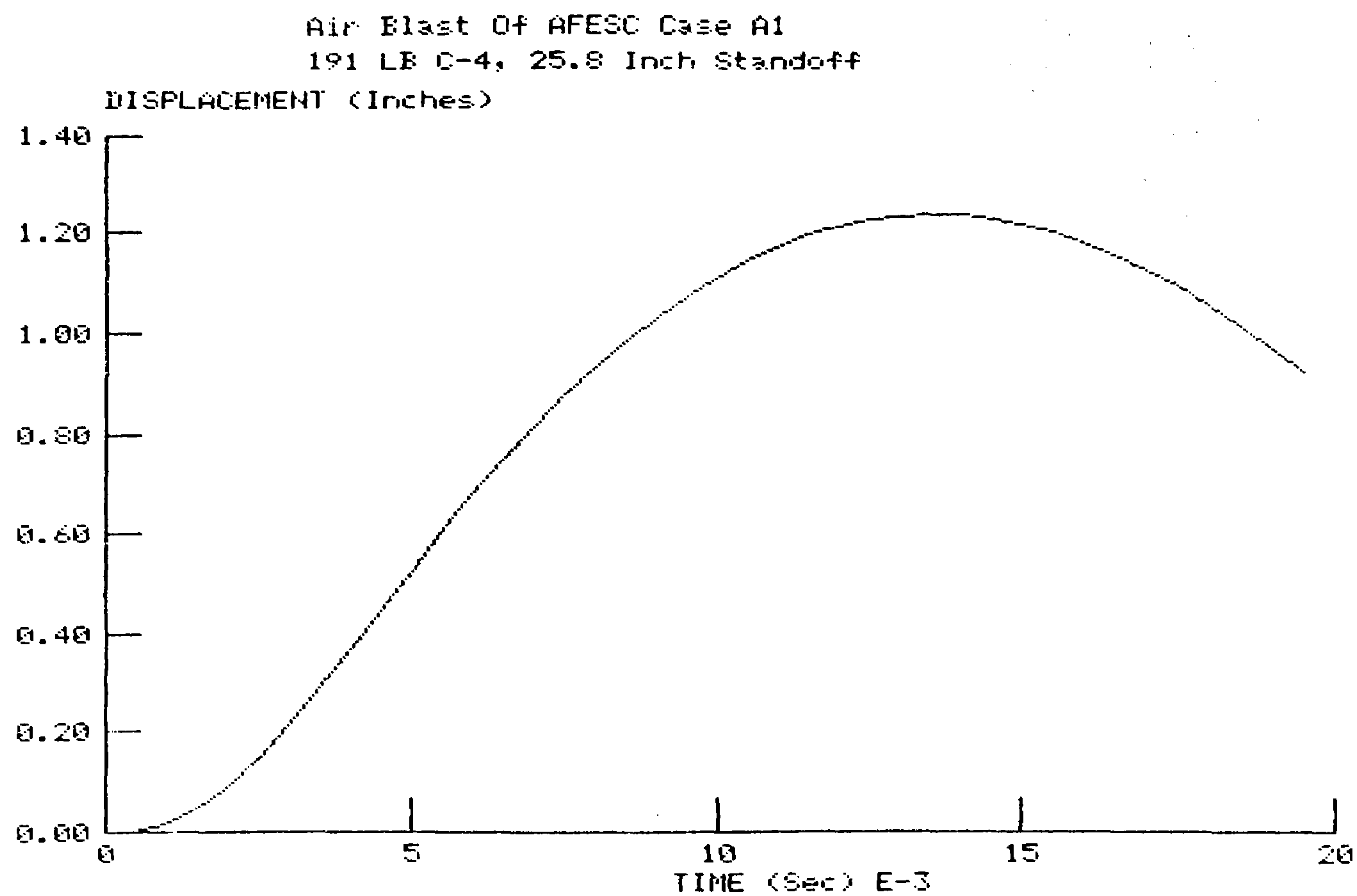


Figure H-8. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Displacement, Time.

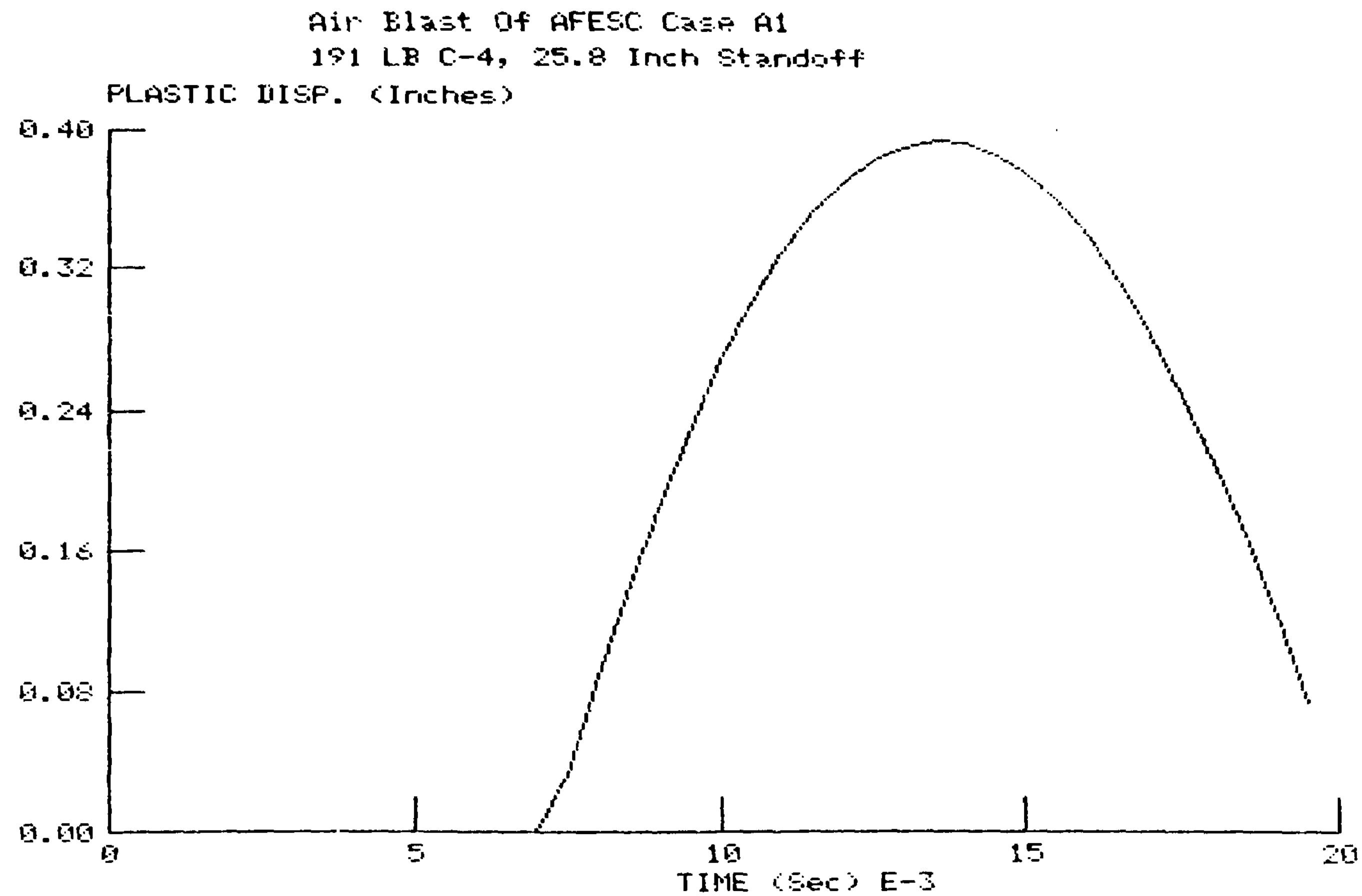


Figure H-9. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Plast. Disp., Time

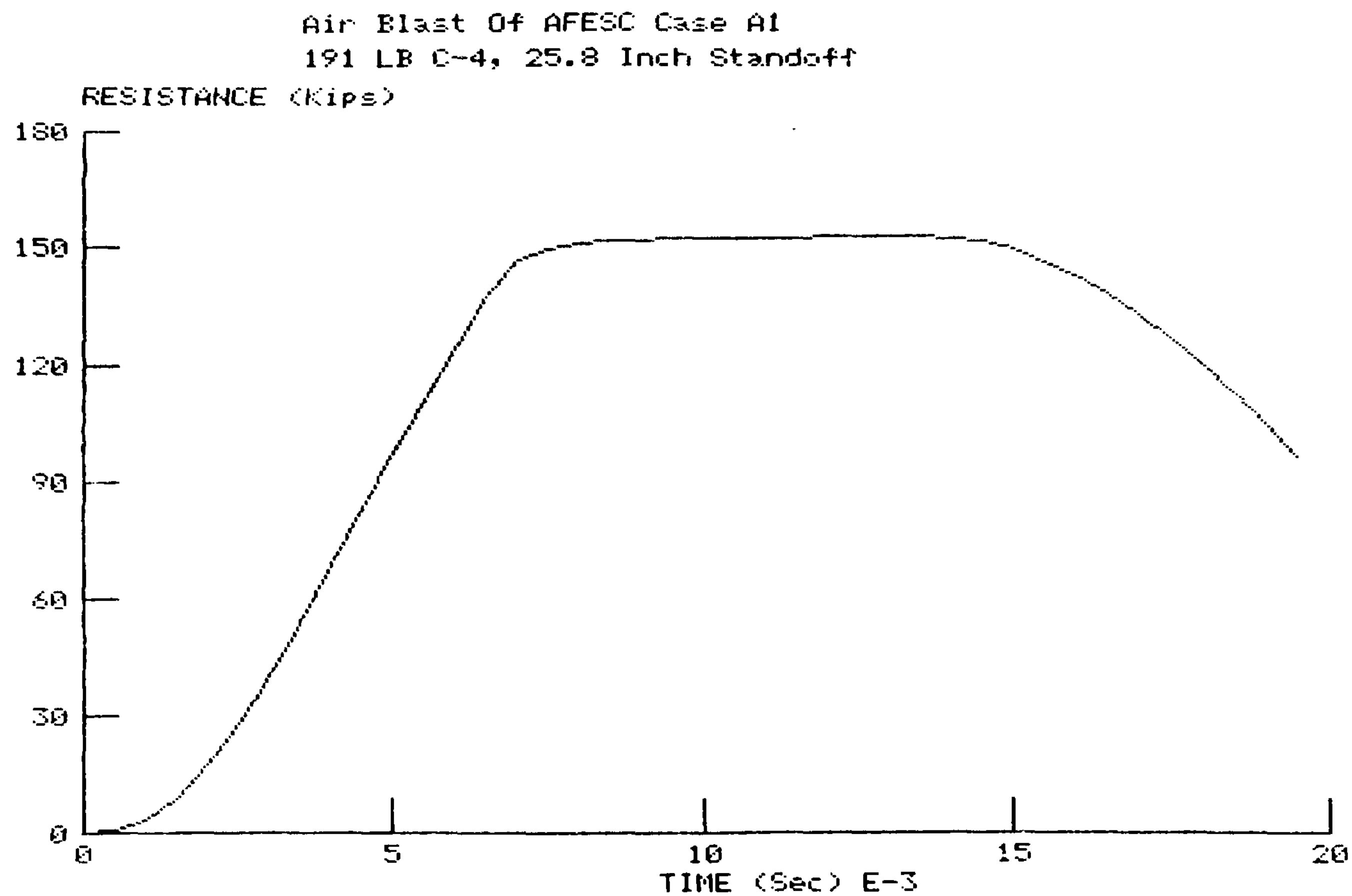


Figure H-10. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Resistance, Time.

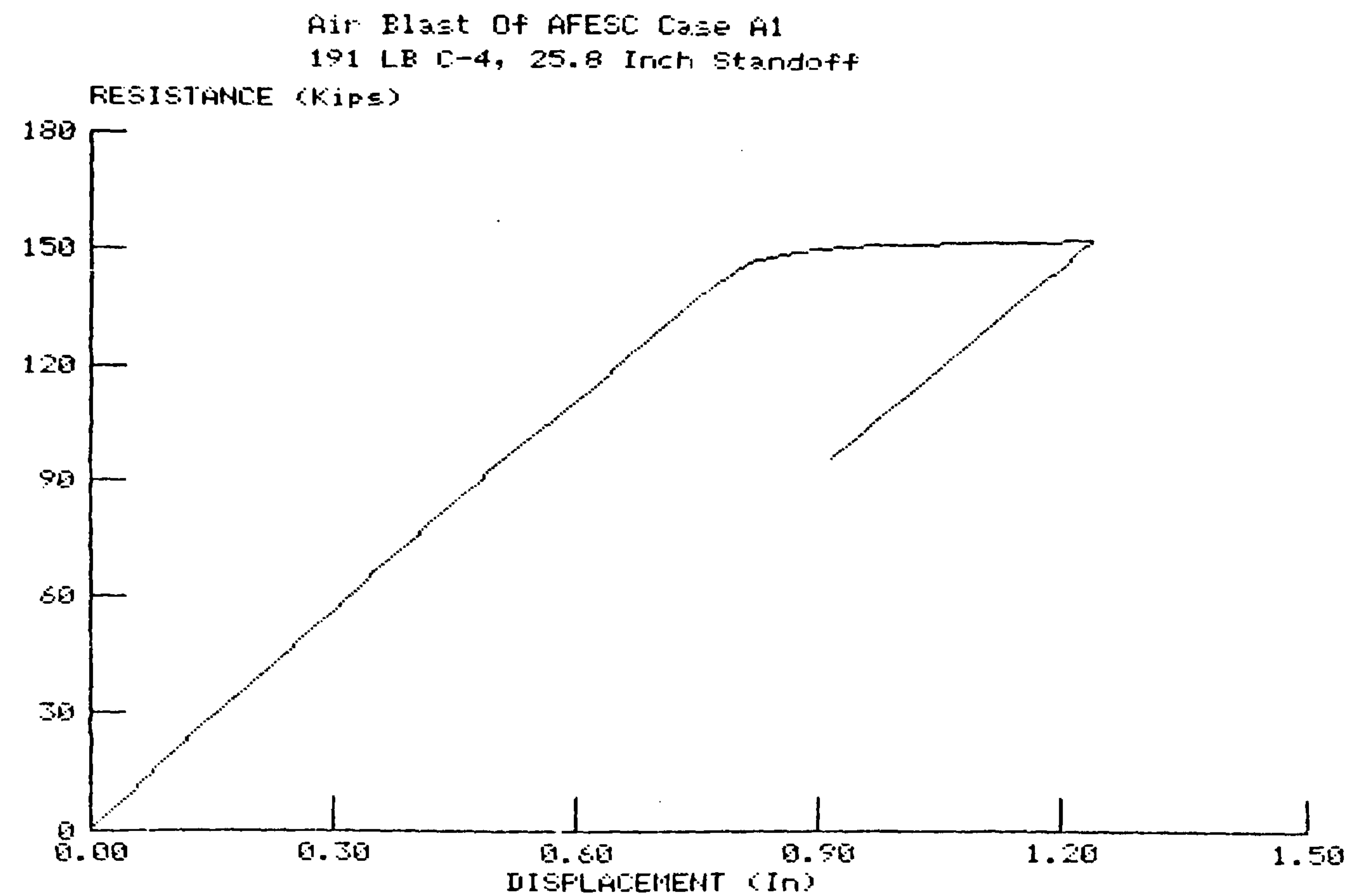


Figure H-11. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Resistance, Disp.

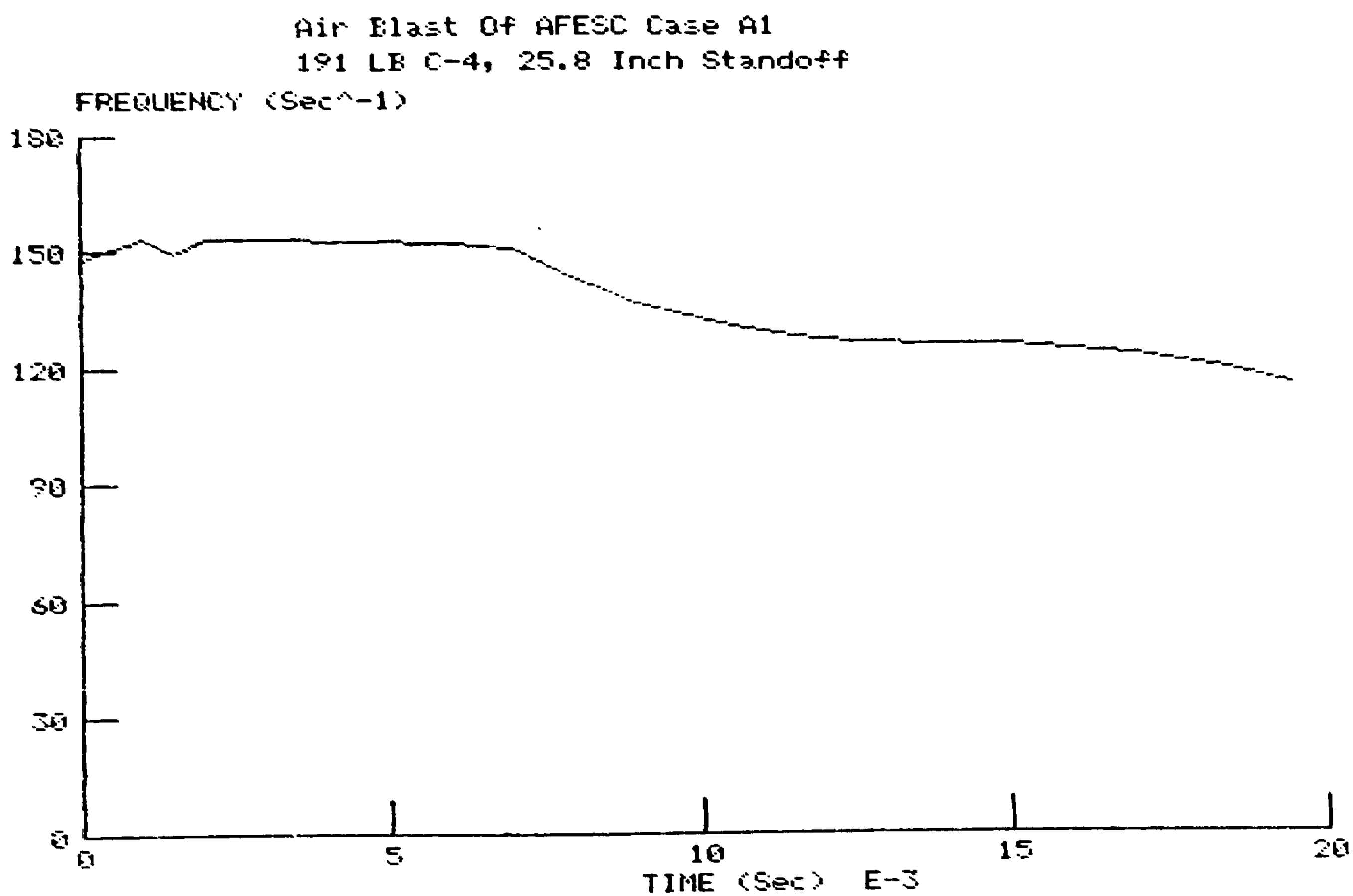


Figure H-12. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Frequency, Time.

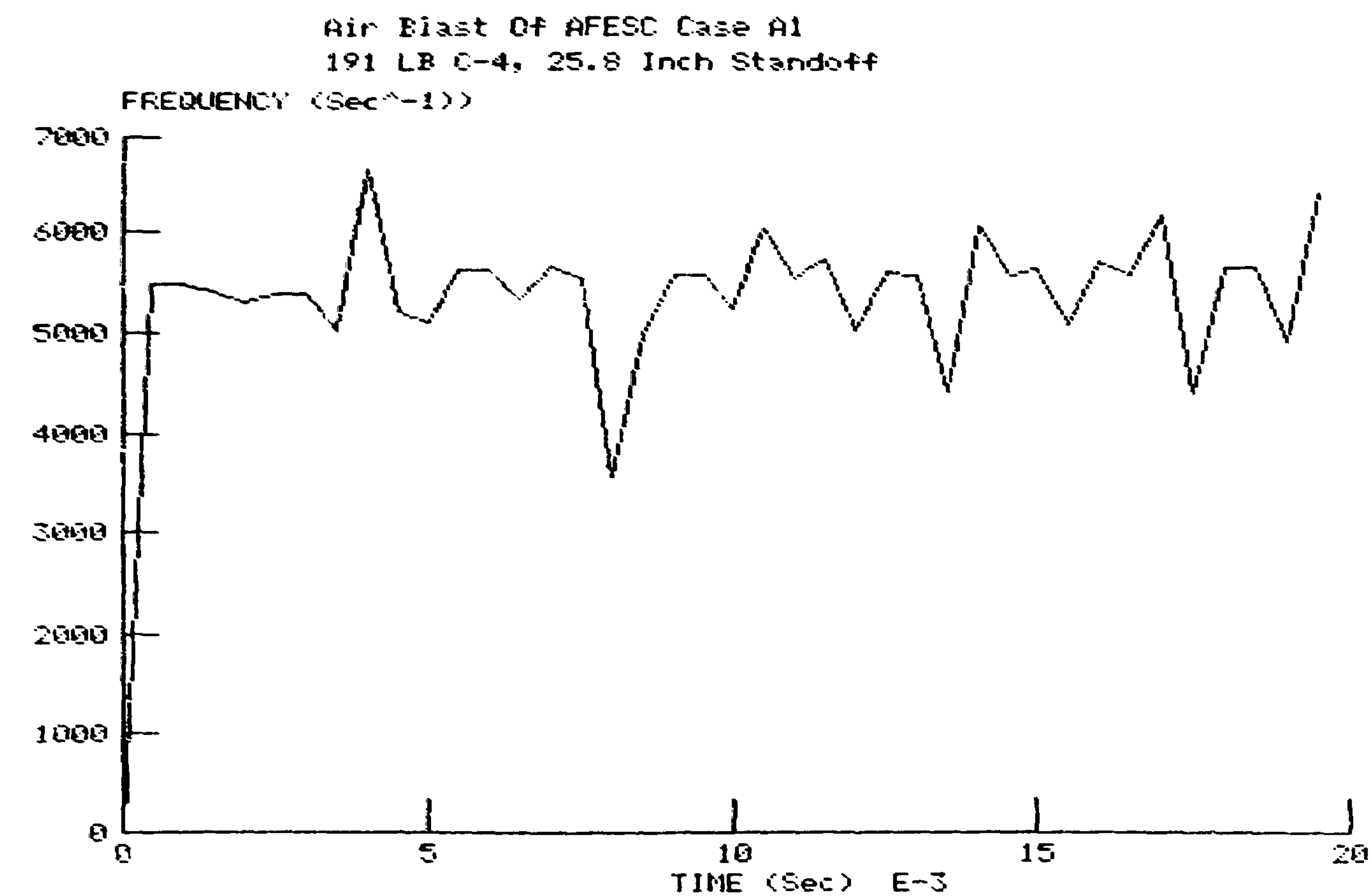


Figure H-12. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Frequency Time (Continued).

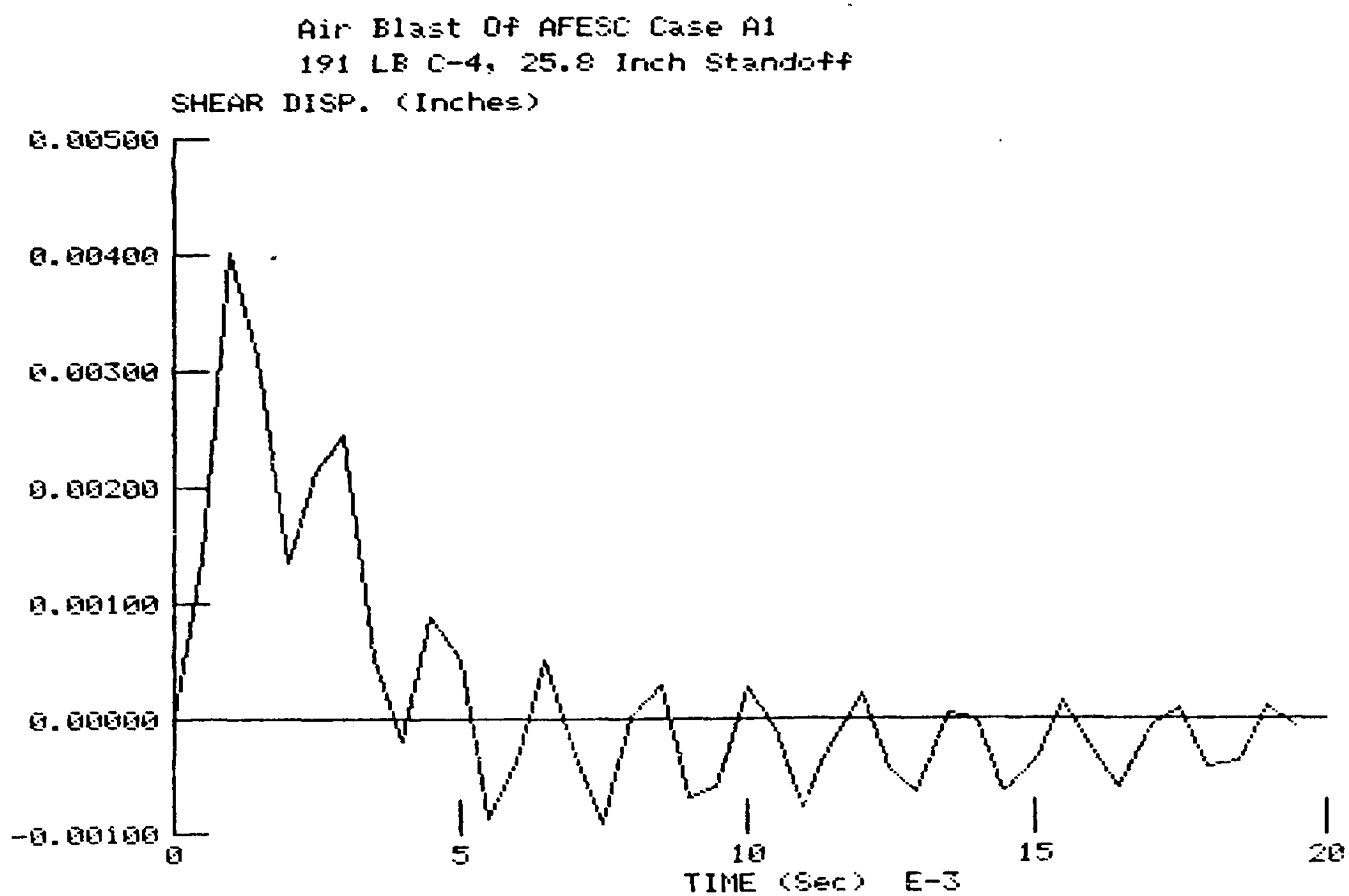


Figure H-13. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Disp., Time

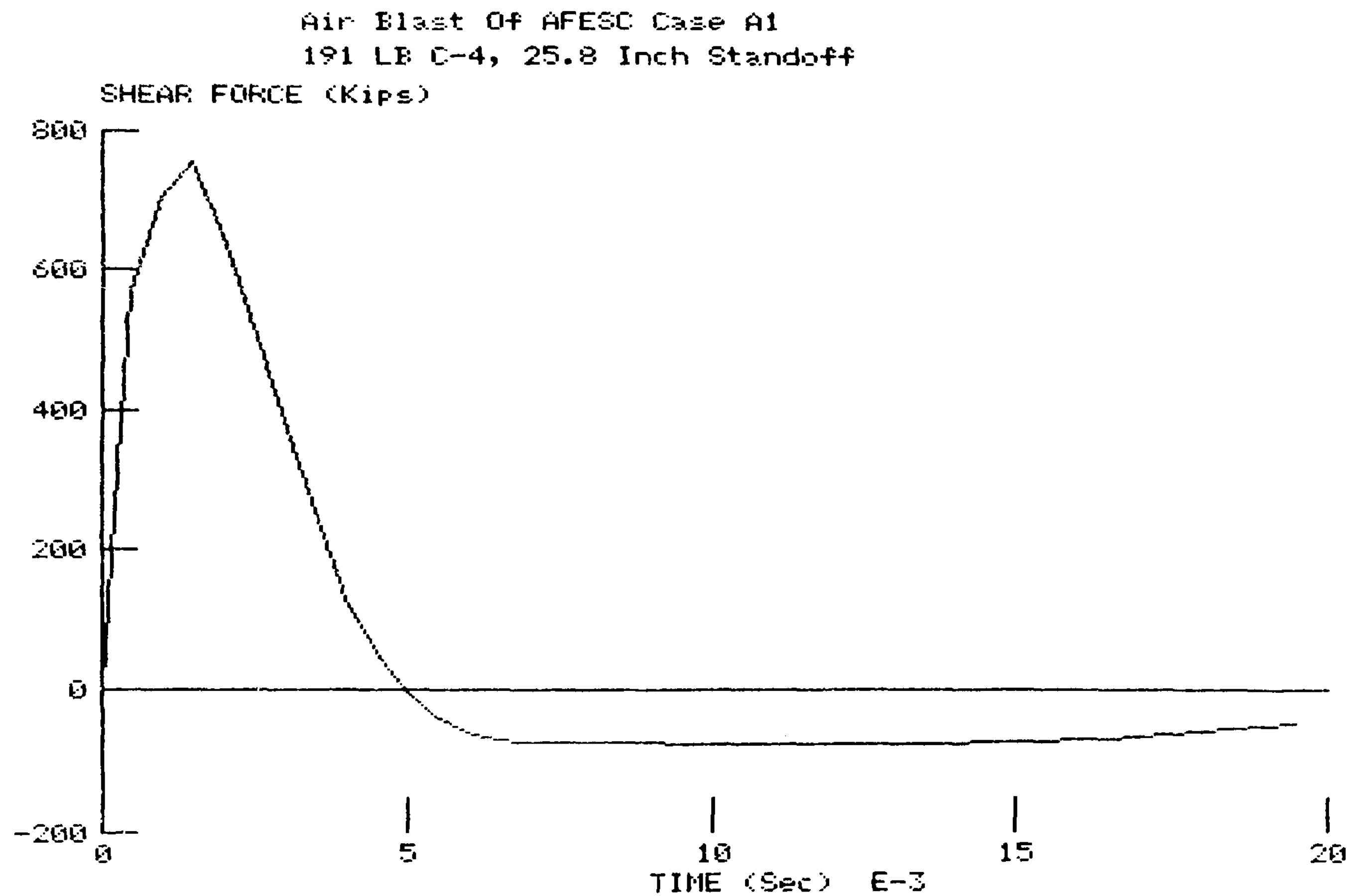


Figure H-14. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Force, Time.

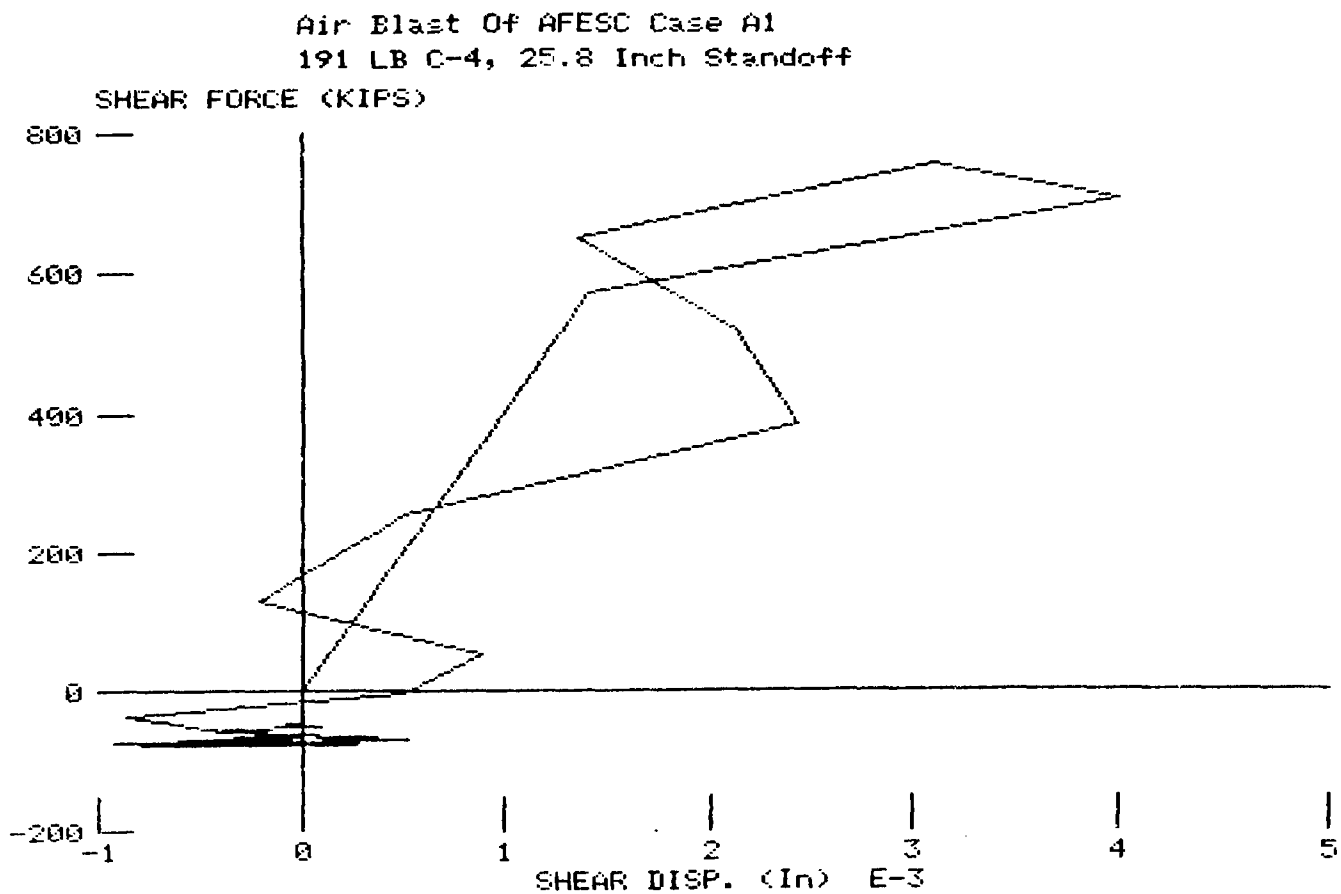


Figure H-15. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Force, Shear Disp.

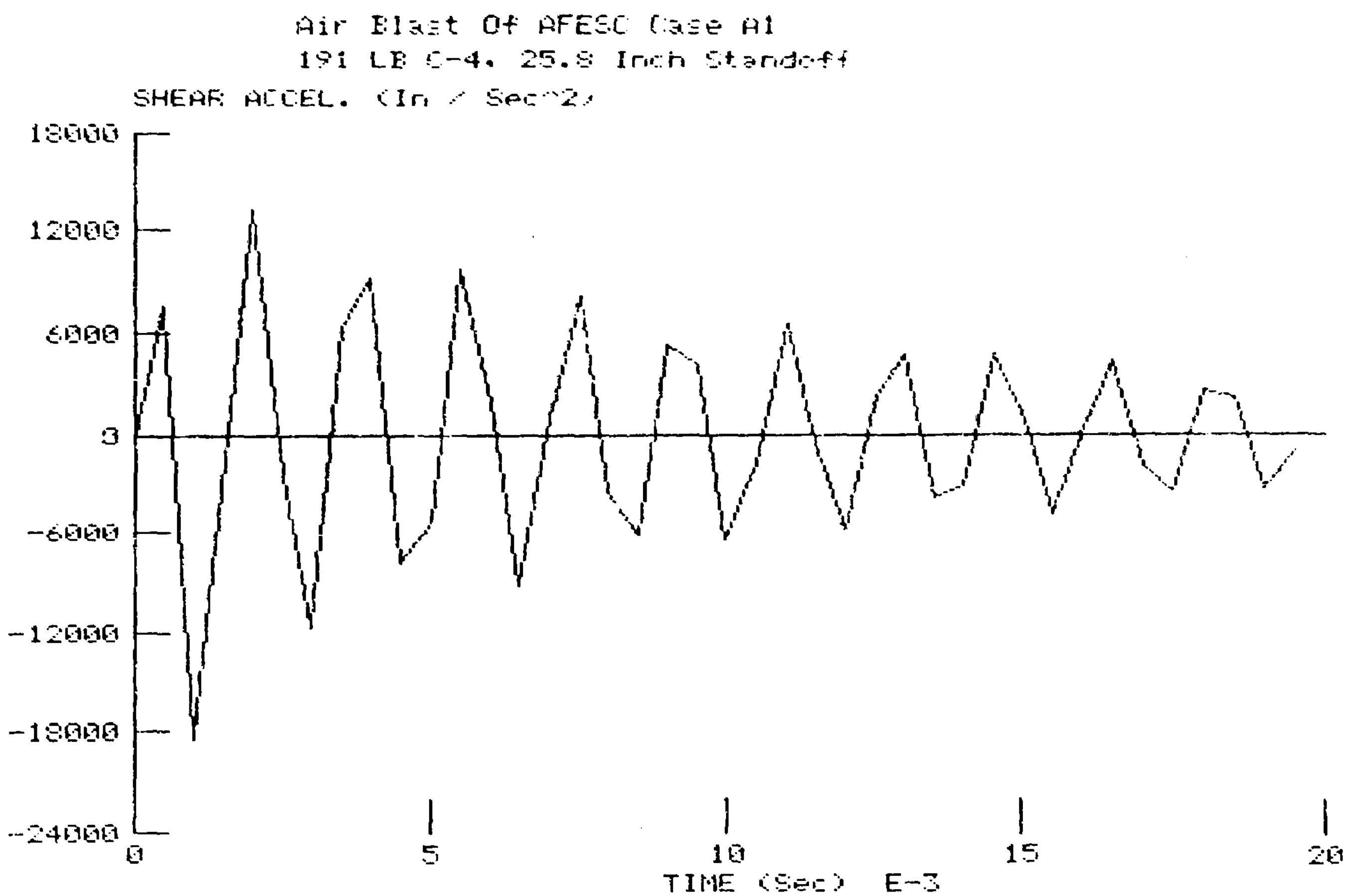


Figure H-16. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Accel., Time

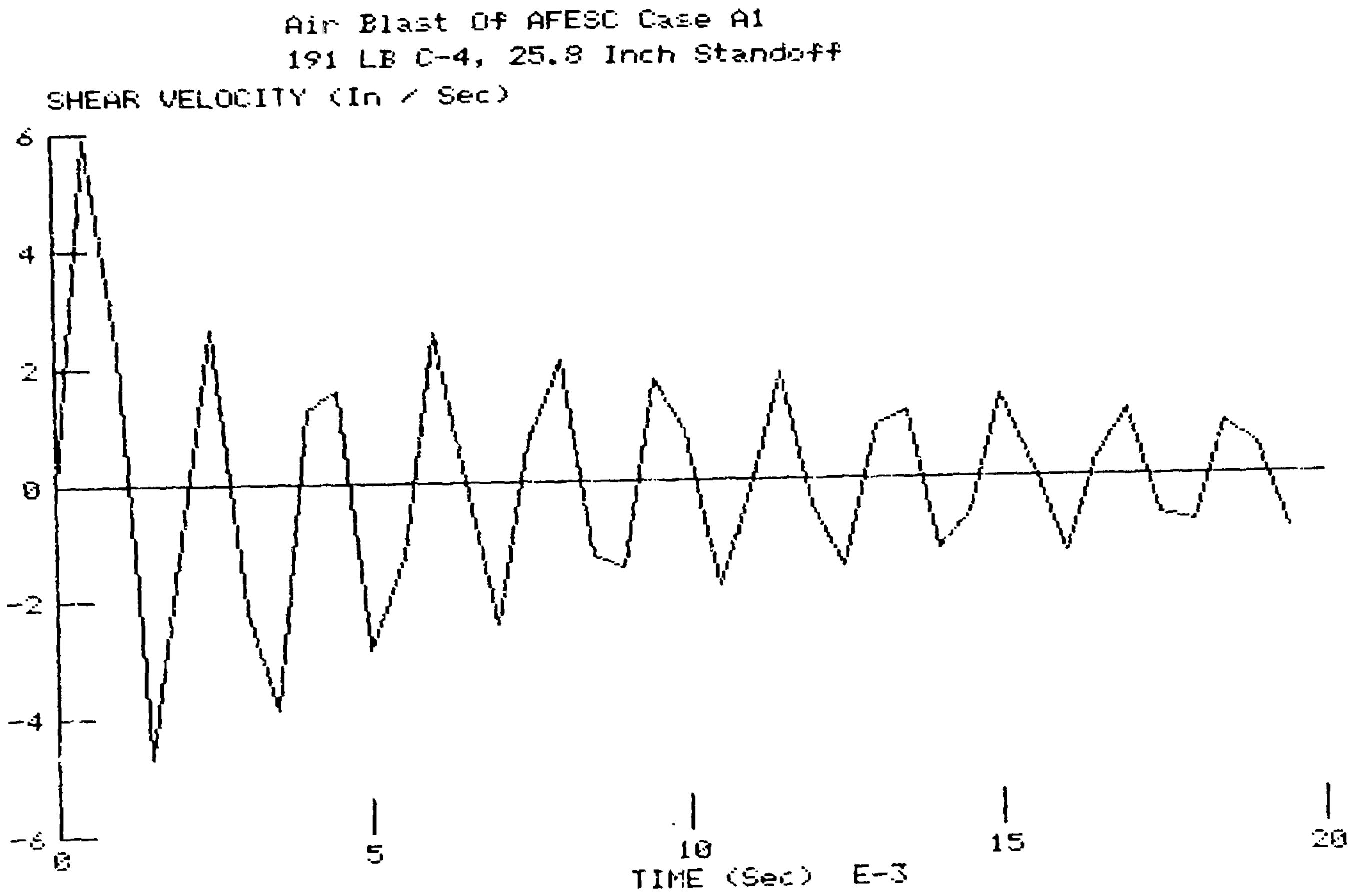


Figure H-17. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Velocity, Time.

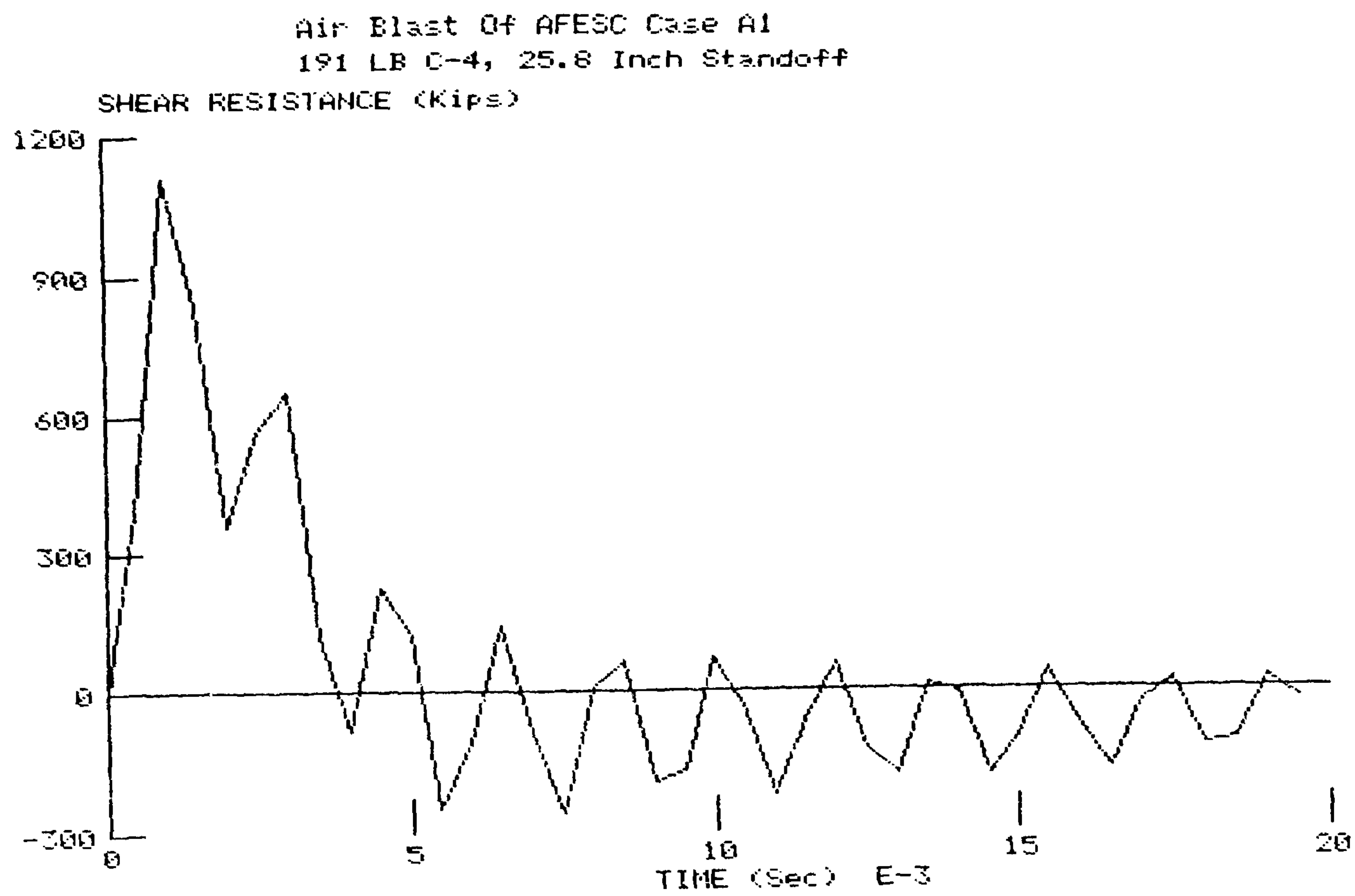


Figure H-18. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Resistance, Time.

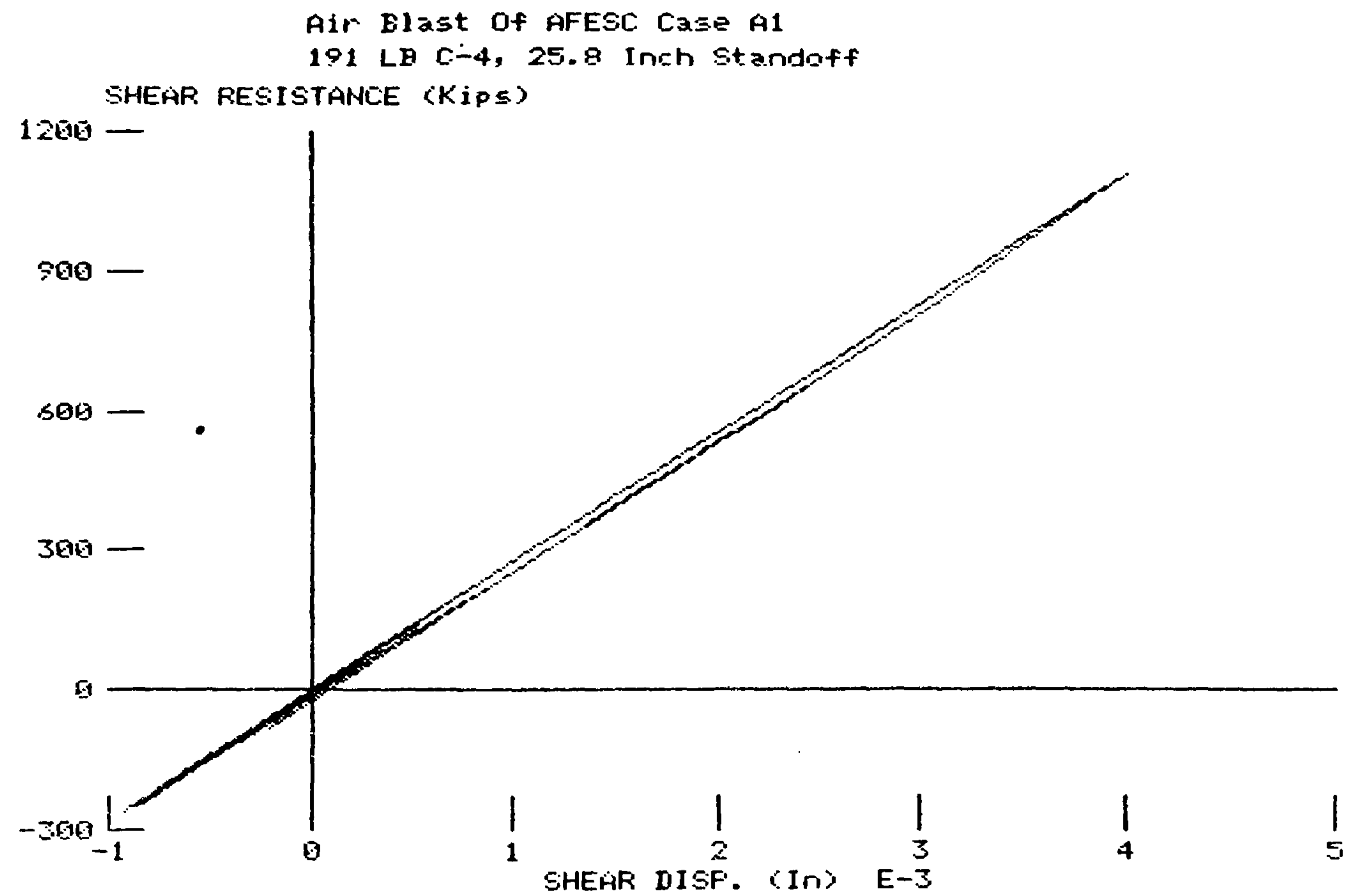


Figure H-19. Air Blast of AFESC Case A-1;
191 Pound C-4, 25.8 Inch Standoff; Shear Resistance, Shear Disp.

(The reverse side of this page is blank.)

APPENDIX I

REICON Code Output

TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA1-2.4 POUND AT 6 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                              PAGE  1

AFESC CASEA1--2.4 LB. AT 6 IN.                                              3  27 1990    9  37  20  57

INPUT VALUES

    PLATE HALF WIDTH OR BEAM HALF SPAN, IN.               (A)  28.000000
    BEAM OR PLATE THICKNESS, IN.                          (H)   4.0000000
    LENGTH TO WIDTH RATIO, DIMENSIONLESS                 (AR)  0.88999999
    MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED         (SMALLM)  0.89859997E-03

    POWER FROM PRESSURE-LAMBDA CURVE                     (FN)  0.82999998
    UNIFORM PRESSURE LOAD, PSI.                          (PU)  0.00000000E+00
    PRESSURE DECAY, DIMENSIONLESS                     (ALPHA)   3.4000001
    PRESSURE DURATION, SEC.                             (TAU)  0.23500000E-03

    SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                   (F)   2.0000000
    WAVE FUNCTION: 1=GENERAL, 2=SQUARE               (WAVEFN)   1.0000000
    WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLM)  0.00000000E+00
    REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4          (RHOR)  0.73390000E-03

    CONCRETE COMPRESSIVE STRENGTH, PSI.              (SIGMAC)   5000.0000
    REINFORCED STEEL YIELD STRESS, PSI.              (SIGMAR)   65000.000
    REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS         (Q)  0.24999999E-02
    REINFORCING DISTANCE, IN.                             (D)   3.3000000

    DIAMETER OF EXPLOSIVE, IN.                         (BIGD)   2.5000000
    PRESSURE INTERCEPT ON P-LAMBDA CURVE             (SMALLK)   5.0000000
    EXPLOSIVE WEIGHT, LBS.                             (BIGW)   2.4000001
    LENGTH OF EXPLOSIVE, IN.                           (BIGL)   8.1499996

    X 1 OF EXPLOSIVE, IN.                               (EX1)   28.000000
    X 2 OF EXPLOSIVE, IN.                               (EX2)   28.000000
    Y 1 OF EXPLOSIVE, IN.                               (EY1)   20.900000
    Y 2 OF EXPLOSIVE, IN.                               (EY2)   29.100000

    Z 1 OF EXPLOSIVE, IN.                               (EZ1)   6.0000000
    Z 2 OF EXPLOSIVE, IN.                               (EZ2)   6.0000000
    SHEAR STIRRUP REINFORMENT RATIO                      (Q1)  0.49999999E-04
    ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                (SMALLA)   2.0000000

    TIME INCREMENT, SEC.                              (TINCR)  0.99999997E-04
    TIME MAXIMUM, SEC.                                 (TMAX)  0.10000000
    TIME STEP INTERVAL PER PRINTED LINE, SEC.        (TPRINT)  0.50000002E-03
    CRITICAL TIME, SEC.                                 (TCR)  0.12000001E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0 ,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
    BEAM HALF WIDTH, IN.                                  (B)   24.920000
    HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)   1562.1230
    WEIGHT PER UNIT AREA, LBS./IN.SQ.                     (W)  0.34721902
```

TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA1-2.4 POUND AT 6 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEA1-2.4 LB. AT 6 IN. 3 27 1990 9 37 22 93

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	2.5754113	1.0438719
10.750001	1.0372064	1.0438719

BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 10.75000 IN.

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEA1-2.4 LB. AT 6 IN. 3 27 1990 9 37 26 12

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999937E-03	0.82155543E-02	501.60373	0.23003580	106007.45	2558.5308	103449.92	28.000000
0.99999933E-03	0.17113382E-01	494.95178	0.47917470	106007.45	5329.5322	100677.92	28.000000
0.14999937E-02	0.25892412E-01	488.29364	0.72498757	106007.45	8063.5405	97943.914	28.000000
0.19999934E-02	0.34552564E-01	481.64789	0.96747458	106007.45	10760.557	95246.898	28.000000
0.24999937E-02	0.43094125E-01	474.99591	1.2066355	106007.45	13420.580	92586.875	28.000000
0.30000030E-02	0.51516301E-01	468.34346	1.4424704	106007.45	16043.611	89963.844	28.000000
0.35000003E-02	0.59820593E-01	461.69202	[illegible]	106007.45	18629.650	87377.805	28.000000
0.40000007E-02	0.68005300E-01	455.04004	1.9041624	106007.45	21170.697	84828.758	28.000000
0.44999938E-02	0.76072119E-01	448.38809	2.1300194	106007.45	23690.750	82316.703	28.000000
0.49999930E-02	0.84019561E-01	441.73602	2.3525505	106007.45	26165.811	79841.641	28.000000
0.54999931E-02	0.91848411E-01	435.08392	2.5717554	106007.45	28603.877	77403.578	28.000000
0.59999973E-02	0.99558368E-01	428.43182	2.7376344	106007.45	31004.951	75002.500	28.000[illegible]
0.64999954E-02	0.10714355	421.77375	3.0001874	106007.45	33369.031	72638.422	28.[illegible]
0.69999956E-02	0.11462194	415.12766	3.2094142	106007.45	35696.117	70311.336	[illegible]
0.74999947E-02	0.12197553	408.47559	3.4153149	106007.45	37986.211	68021.242	[illegible]
0.79999939E-02	0.12921034	401.82349	3.6178894	106007.45	40239.312	65768.141	28.000000
0.84999930E-02	0.13632537	395.17139	3.8171384	106007.45	42455.422	63552.031	28.000000
0.89999922E-02	0.14332360	388.51932	4.0130606	106007.45	44634.535	61372.918	28.000000
0.94999913E-02	0.15020205	381.86722	4.2056575	106007.45	46776.656	59230.797	28.000000
0.99999905E-02	0.15696172	375.21512	4.3949285	106007.45	48881.785	57125.668	28.000000
0.10499930E-01	0.16360259	368.56305	4.5806725	106007.45	50949.918	55057.535	28.000000
0.10999939E-01	0.17012468	361.91095	4.7634912	106007.45	52981.059	53026.395	28.000000
0.11499938E-01	0.17652799	355.25885	4.9427838	106007.45	54975.207	51032.246	28.000000
0.11999937E-01	0.18281250	348.60678	5.1187501	106007.45	56932.359	49075.094	28.000000
0.12499936E-01	0.18897822	341.95468	5.2913904	106007.45	58852.520	47154.934	28.000000
0.12999935E-01	0.19502518	335.30261	5.4607048	106007.45	60735.687	45271.766	28.000000

TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA1-2.4 POUND AT 6 INCHES (Continued).

0.13499985E-01	0.20095332		328.65051	5.6266928	106007.45	62581.859	43425.534	28.000000
0.13999984E-01	0.20676269		321.99841	5.7893553	106007.45	64391.039	41616.414	28.000000
0.14499983E-01	0.21245328		315.34634	5.9486918	106007.45	66163.227	39844.227	28.000000
0.14999982E-01	0.21802506		308.69424	6.1047015	106007.45	67898.422	38109.031	28.000000
0.15499981E-01	0.22347806		302.04218	6.2573857	106007.45	69596.625	36410.828	28.000000
0.15999980E-01	0.22881229		295.39008	6.4067440	106007.45	71257.836	34749.617	28.000000
0.16499979E-01	0.23402771		288.73798	6.5527759	106007.45	72882.047	33125.406	28.000000
0.16999979E-01	0.23912436		282.08591	6.6954823	106007.45	74469.266	31538.187	28.000000
0.17499978E-01	0.24410221	*	275.43381	6.8348618	106007.45	76019.492	29987.961	28.000000

MAXIMUM DEFLECTION = 9.6859446 AT TIME = 0.38300075E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES.

```
                                                                                    PAGE  1
     CALCULATIONS ON A CONCRETE BEAM
                                                                     3  27 1990    9  41  29  49
     AFESC CASEA2--2.4 LB. AT 12 IN.

INPUT VALUES

     PLATE HALF WIDTH OR BEAM HALF SPAN, IN.            (A)  28.000000
     BEAM OR PLATE THICKNESS, IN.                       (H)  4.0000000
     LENGTH TO WIDTH RATIO, DIMENSIONLESS              (AR)  0.08999999
     MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED      (SMALLM)  0.89659997E-03

     POWER FROM PRESSURE-LAMBDA CURVE                  (FN)  1.0000000
     UNIFORM PRESSURE LOAD, PSI.                       (PU)  0.00000000E+00
     PRESSURE DECAY, DIMENSIONLESS                  (ALPHA)  3.5000000
     PRESSURE DURATION, SEC.                          (TAU)  0.20200000E-03

     SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                (F)  2.0000000
     WAVE FUNCTION: 1=GENERAL, 2=SQUARE             (WAVEFN)  1.0000000
     WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
     REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4      (RHOR)  0.73390000E-03

     CONCRETE COMPRESSIVE STRENGTH, PSI.          (SIGMAC)  5000.0000
     REINFORCED STEEL YIELD STRESS, PSI.          (SIGMAR)  65000.000
     REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS    (U)  0.24999995E-02
     REINFORCING DISTANCE, IN.                          (D)  3.3000000

     DIAMETER OF EXPLOSIVE, IN.                      (BIGD)  2.5000000
     PRESSURE INTERCEPT ON P-LAMBDA CURVE          (SMALLK)  5.0000000
     EXPLOSIVE WEIGHT, LBS.                          (BIGW)  2.4000001
     LENGTH OF EXPLOSIVE, IN.                        (BIGL)  4.1499996

     X 1 OF EXPLOSIVE, IN.                            (EX1)  28.000000
     X 2 OF EXPLOSIVE, IN.                            (EX2)  28.000000
     Y 1 OF EXPLOSIVE, IN.                            (EY1)  20.900000
     Y 2 OF EXPLOSIVE, IN.                            (EY2)  29.100000

     Z 1 OF EXPLOSIVE, IN.                            (EZ1)  12.000000
     Z 2 OF EXPLOSIVE, IN.                            (EZ2)  12.000000
     SHEAR STIRRUP REINFORMENT RATIO                   (Q1)  0.49999999E-04
     ENVIRONMENT FACTOR: 1=SOIL, 2=AIR             (SMALLA)  2.0000000

     TIME INCREMENT, SEC.                           (TINCR)  0.99999997E-04
     TIME MAXIMUM, SEC.                              (TMAX)  0.10000000
     TIME STEP INTERVAL PER PRINTED LINE, SEC.     (TPRINT)  0.50000002E-03
     CRITICAL TIME, SEC.                              (TCR)  0.12000001E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
      BEAM HALF WIDTH, IN.                              (B)  24.920000
      HINGE MOMENT, IN.-LBS./IN.                    (BIGMU)  1562.1230
      WEIGHT PER UNIT AREA, LBS./IN.SQ.                 (W)  0.34721902
```

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XX) 20.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

PAGE 2

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION

3 27 1990 9 41 32 90

AFESC CASEA2--2.4 LB. AT 12 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS 1 BAR 2 CRITICAL

1.0000000 0.7306406E4 1.0430719

PAGE 3

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

3 27 1990 9 41 33 39

AFESC CASEA2--2.4 LB. AT 12 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	HGPT. VEL. (IN./SEC.)	HGPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	20.000000
0.49999997E-03	0.55822714E-02	334.36311	0.15634362	4659.141	1730.4?01	45120.604	20.000000
0.99999993E-03	0.11493564E-01	327.71704	0.32383575	4659.141	3573.4409	43279.695	20.000000
[illegible]	0.17206453E-01	321.06494	0.48482965	4659.141	5303.4307	41475.711	20.000000
[illegible]	0.22980357E-01	314.41254	0.64300498	4659.141	7120.4272	39700.715	20.000000
[illegible]	[illegible]	307.75627	0.79843348	4659.141	[illegible]	37970.711	20.000000
[illegible]	[illegible]	301.10067	0.95063913	4659.141	10573.439	36305.703	20.000000
[illegible]	[illegible]	294.45668	1.0995424	4659.141	12239.456	34629.604	20.000000
[illegible]	[illegible]	287.80458	1.2451975	4659.141	13940.479	33010.664	20.000000
[illegible]	[illegible]	281.15240	[illegible]	4659.141	15430.508	31420.633	20.000000
[illegible]	[illegible]	274.50034	[illegible]	4659.141	[illegible]	29883.598	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	28375.555	20.000000
[illegible]	[illegible]	261.[illegible]	[illegible]	4659.141	[illegible]	26904.506	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	21500.[illegible]	25470.449	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	24073.305	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	22713.319	20.000000
[illegible]	[illegible]	[illegible]	2.1790752	4659.141	[illegible]	21390.230	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	20104.154	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	18855.064	20.000000
[illegible]	[illegible]	[illegible]	2.5178598	4659.141	[illegible]	17642.969	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	16467.065	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	15328.759	20.000000
[illegible]	[illegible]	201.[illegible]	[illegible]	4659.141	[illegible]	14228.637	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	13164.512	20.000000
[illegible]	[illegible]	[illegible]	3.1230289	4659.141	[illegible]	12137.379	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	11147.230	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	10194.094	20.000000
[illegible]	[illegible]	[illegible]	[illegible]	4659.141	[illegible]	9277.9914	20.000000
[illegible]	[illegible]	154.[illegible]	[illegible]	4659.141	[illegible]	8398.7812	20.000000
[illegible]	[illegible]	[illegible]	3.5336645	4659.141	[illegible]	7556.6133	20.000000

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES (Continued).

0.14999982E-01	0.13207876	141.45941	3.6464572	46859.141	40102.783	6751.4375	20.000000
0.15499981E-01	0.13325492	134.00739	3.6751237	46859.141	40875.082	5983.2539	20.000000
0.15999980E-01	0.13368231	130.15536	3.7400645	46859.141	41600.674	5252.0664	20.000000
0.16499979E-01	0.13383140	121.58334	3.8052752	46859.141	42301.270	4557.8711	20.000000
0.16999979E-01	0.13594170	114.35132	3.8623676	46859.141	42950.473	3900.6680	20.000000
0.17499978E-01	0.13793324	108.15930	3.9101309	46859.141	43570.604	3280.4570	20.000000
0.17999977E-01	0.14090590	101.54720	3.9705672	46859.141	44161.982	2697.2383	20.000000
0.18499976E-01	0.14255392	94.695256	4.0196776	46859.141	44708.125	2151.0156	20.000000
0.18999975E-01	0.14519510	88.243233	4.0654626	46859.141	45217.355	1641.7852	20.000000
0.19499974E-01	0.14671147	81.591217	4.1073211	46859.141	45689.594	1169.5469	20.000000
0.19999973E-01	0.14810985	74.939194	4.1478532	46859.141	46124.040	734.30078	20.000000
0.20499973E-01	0.14930787	68.287170	4.1828609	46859.141	46523.094	336.07617	20.000000
0.20999972E-01	0.15054709	61.635147	4.2153911	46859.141	46884.352	-25.210937	20.000000
0.21499971E-01	0.15150911	54.983120	4.2449949	46859.141	47206.617	-349.47656	20.000000
0.21999970E-01	0.15251157	48.331100	4.2703238	46859.141	47495.091	-636.75000	20.000000
0.22499969E-01	0.15331523	41.675095	4.2928567	46859.141	47746.172	-887.03125	20.000000
0.22999968E-01	0.15400110	35.027061	4.3120031	46859.141	47959.461	-1100.3203	20.000000
0.23499968E-01	0.15456420	28.375042	4.3278532	46859.141	48135.754	-1276.6133	20.000000
0.23999967E-01	0.15501350	21.723013	4.3403770	46859.141	48275.055	-1415.9141	20.000000
0.24499966E-01	0.15534201	15.070982	4.3495765	46859.141	48377.363	-1518.2227	20.000000
0.24999965E-01	0.15555175	8.4189562	4.3554407	46859.141	48442.640	-1583.5391	20.000000
0.25499964E-01	0.15564270	1.7669296	4.3579955	46859.141	48471.004	-1611.6633	20.000000

MAXIMUM DEFLECTION = 4.3580020 AT TIME = 0.25499964E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA3-2.4 POUND AT 18 INCHES.

```
                                                                                                  PAGE  1
        CALCULATIONS ON A CONCRETE BEAM
                                                                                  3   27 1990    9   43    7   97
       AFESC CASEA3--2.4 LB. AT 18 IN.

    INPUT VALUES

        PLATE HALF WIDTH OR BEAM HALF SPAN, IN.              (A)  28.000000
        BEAM OR PLATE THICKNESS, IN.                         (H)  4.0000000
        LENGTH TO WIDTH RATIO, DIMENSIONLESS                (AR) 0.88999999
        MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED       (SMALLM) 0.89859997E-03

        POWER FROM PRESSURE-LAMBDA CURVE                    (FN)  1.1500000
        UNIFORM PRESSURE LOAD, PSI.                         (PU) 0.00000000E+00
        PRESSURE DECAY, DIMENSIONLESS                    (ALPHA)  4.3000002
        PRESSURE DURATION, SEC.                            (TAU) 0.26199999E-03

        SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                  (F)  2.0000000
        WAVE FUNCTION: 1=GENERAL, 2=SQUARE              (WAVEFN)  1.0000000
        WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN) 0.00000000E+00
        REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4         (RHOR) 0.73390000E-03

        CONCRETE COMPRESSIVE STRENGTH, PSI.             (SIGMAC)  5000.0000
        REINFORCED STEEL YIELD STRESS, PSI.             (SIGMAR)  65000.000
        REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS      (Q) 0.24999999E-02
        REINFORCING DISTANCE, IN.                            (D)  3.3000000

        DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  2.5000000
        PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLK)  5.0000000
        EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.4000001
        LENGTH OF EXPLOSIVE, IN.                          (BIGL)  8.1499996

        X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
        X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
        Y 1 OF EXPLOSIVE, IN.                              (EY1)  20.900000
        Y 2 OF EXPLOSIVE, IN.                              (EY2)  29.100000

        Z 1 OF EXPLOSIVE, IN.                              (EZ1)  18.000000
        Z 2 OF EXPLOSIVE, IN.                              (EZ2)  18.000000
        SHEAR STIRRUP REINFORMENT RATIO                     (Q1) 0.49999999E-04
        ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLA)  2.0000000

        TIME INCREMENT, SEC.                             (TINCR) 0.99999997E-04
        TIME MAXIMUM, SEC.                                (TMAX) 0.10000000
        TIME STEP INTERVAL PER PRINTED LINE, SEC.       (TPRINT) 0.50000002E-03
        CRITICAL TIME, SEC.                                (TCR) 0.12000001E-02

    COMPUTED CONSTANT VALUES
        BEAM HALF WIDTH, IN.                                 (B)  24.920000
        HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  1562.1230
        WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W) 0.34721902
        ORIGINAL HINGE LOCATION, IN.                        (XH)  25.836185

        CLAMPED-SUPPORTED         GENERAL TIME FUNCTION          VERTICAL WALL              BLAST LOAD
```

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA3-2.4 POUND AT 18 INCHES (Continued).

PAGE 2

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION

3 27 1990   9 43 15 99

AFESC CASEA3--2.4 LB. AT 18 IN.

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.35357293	1.0438719

PAGE 3

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

3 27 1990   9 43 16 65

AFESC CASEA3--2.4 LB. AT 18 IN.

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	25.836185
0.49999937E-03	0.40505547E-02	232.43315	0.10624950	25519.523	1261.4432	24258.080	26.230852
0.99999933E-03	0.83435131E-02	232.43315	0.22246605	25519.523	2598.3772	22921.146	26.663355
0.14999937E-02	0.12498875E-01	232.43315	0.33868259	25519.523	3892.4600	21627.062	27.097046
0.19999934E-02	0.16523283E-01	221.87985	0.46265191	25519.523	5145.7603	20373.764	28.000000
0.24999937E-02	0.20426027E-01	215.22783	0.57192874	25519.523	6361.1724	19158.352	28.000000
0.30000000E-02	0.24209391E-01	208.57581	0.67787975	25519.523	7539.5923	17979.932	28.000000
0.35000003E-02	0.27875165E-01	201.92378	0.78050458	25519.523	8681.0195	16838.504	28.000000
0.40000007E-02	0.31421553E-01	195.27176	0.87980348	25519.523	9785.4531	15734.070	28.000000
0.44999938E-02	0.34849156E-01	188.61974	0.97577637	25519.523	10852.894	14666.630	28.000000
0.49999930E-02	0.38157373E-01	181.96771	1.0684233	25519.523	11883.341	13636.183	28.000000
0.54999931E-02	0.41348003E-01	175.31569	1.1577441	25519.523	12876.796	12642.728	28.000000
0.59999973E-02	0.44419248E-01	168.66367	1.2437389	25519.523	13833.258	11686.266	28.000000
0.64999954E-02	0.47371704E-01	162.01166	1.3?64077	25519.523	14752.727	10766.797	28.000000
0.69999976E-02	0.50205380E-01	155.35963	1.40[illegible]	25519.523	15635.203	9884.3203	28.000000
0.74999947E-02	0.52920263E-01	148.70761	1.4817674	25519.523	16480.686	9038.8379	28.000000
0.79999939E-02	0.55516366E-01	142.05559	1.5544583	25519.523	17289.176	8230.3477	28.000000
0.84999930E-02	0.57993680E-01	135.40356	1.6238230	25519.523	18060.674	7458.8496	28.000000
0.89999922E-02	0.60352206E-01	128.75154	1.6898618	25519.523	18795.178	6724.3457	28.000000
0.94999913E-02	0.62591348E-01	122.09953	1.7525746	25519.523	19492.689	6026.8340	28.000000
0.99999905E-02	0.64712304E-01	115.44750	1.8119613	25519.523	20153.207	5366.3164	28.000000
0.10499990E-01	0.66715077E-01	108.79548	1.8680222	25519.523	20776.732	4742.7910	28.000000
0.10999989E-01	0.68598457E-01	102.14346	1.9207568	25519.523	21363.266	4156.2578	28.000000
0.11499988E-01	0.70363060E-01	95.491440	1.9701657	25519.523	21912.805	3606.7187	28.000000
0.11999987E-01	0.72008871E-01	88.839417	2.0162485	25519.523	22425.352	3094.1719	28.000000
0.12499986E-01	0.73535089E-01	82.187393	2.0590048	25519.523	22900.904	2618.6191	28.000000
0.12999985E-01	0.74944131E-01	75.535370	2.0984356	25519.523	23339.465	2180.0586	28.000000
0.13499985E-01	0.76233581E-01	68.883354	2.1345403	25519.523	23741.033	1778.4902	28.000000
0.13999984E-01	0.77404246E-01	62.231331	2.1673188	25519.523	24105.607	1413.9160	28.000000
0.14499983E-01	0.78456126E-01	55.579308	2.1967716	25519.523	24433.189	1086.3340	28.000000
0.14999982E-01	0.79389222E-01	48.927288	2.2228982	25519.523	24723.779	795.74414	28.000000
0.15499981E-01	0.80203526E-01	42.275269	2.2456987	25519.523	24977.375	542.14844	28.000000
0.15999980E-01	0.80899052E-01	35.623245	2.2651734	25519.523	25193.979	325.54492	28.000000

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA3-2.4 POUND AT 18 INCHES (Continued).

0.16499979E-01	0.81475787E-01	28.971224	2.2813220	25519.523	25373.538	145.93555	28.000000
0.16999979E-01	0.81933737E-01	22.319195	2.2941446	25519.523	25516.205	3.3183594	28.000000
0.17499978E-01	0.82272902E-01	15.667164	2.3036413	25519.523	25621.830	-102.30664	28.000000
0.17999977E-01	0.82493275E-01	9.0151377	2.3098116	25519.523	25690.461	-170.93750	28.000000
0.18499976E-01	0.82594872E-01	2.3631105	2.3126564	25519.523	25722.100	-202.57617	28.000000

MAXIMUM DEFLECTION = 2.3128629 AT TIME = 0.18699976E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4 .8 POUND AT 7 INCHES.

```
                                                                                        PAGE  1
CALCULATIONS ON A CONCRETE BEAM
                                                                     3  27 1990    9  45  5  40
AFESC CASEA4--2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                 (A)  28.000000
BEAM OR PLATE THICKNESS, IN.                            (H)  4.0000000
LENGTH TO WIDTH RATIO, DIMENSIONLESS                   (AR)  0.88999999
MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED          (SMALLM)  0.85859997E-03

POWER FROM PRESSURE-LAMBDA CURVE                       (FN)  1.0000000
UNIFORM PRESSURE LOAD, PSI.                           (CU)  0.00000000E+00
PRESSURE DECAY, DIMENSIONLESS                       (ALPHA)  3.4000001
PRESSURE DURATION, SEC.                               (TAU)  0.24500000E-03

SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                     (F)  2.0000000
WAVE FUNCTION: 1=GENERAL, 2=SQUARE                  (WAVEFN)  1.0000000
WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4            (RHOR)  0.73390000E-03

CONCRETE COMPRESSIVE STRENGTH, PSI.                (SIGMAC)  5900.0000
REINFORCED STEEL YIELD STRESS, PSI.                (SIGMAR)  65000.000
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS          (Q)  0.24999999E-02
REINFORCING DISTANCE, IN.                              (D)  3.3000000

DIAMETER OF EXPLOSIVE, IN.                          (BIGD)  3.2500000
PRESSURE INTERCEPT ON P-LAMBDA CURVE              (SMALLK)  5.0000000
EXPLOSIVE WEIGHT, LBS.                              (BIGW)  2.8000000
LENGTH OF EXPLOSIVE, IN.                            (BIGL)  5.6300001

X 1 OF EXPLOSIVE, IN.                               (EX1)  28.000000
X 2 OF EXPLOSIVE, IN.                               (EX2)  28.000000
Y 1 OF EXPLOSIVE, IN.                               (EY1)  23.400000
Y 2 OF EXPLOSIVE, IN.                               (EY2)  27.799999

Z 1 OF EXPLOSIVE, IN.                               (EZ1)  7.0000000
Z 2 OF EXPLOSIVE, IN.                               (EZ2)  7.0000000
SHEAR STIRRUP REINFORCEMENT RATIO                    (U1)  0.49999999E-04
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                (SMALLA)  2.0000000

TIME INCREMENT, SEC.                              (TINCR)  0.99999997E-04
TIME MAXIMUM, SEC.                                 (TMAX)  0.10000000
TIME STEP INTERVAL PER PRINTED LINE, SEC.        (TPRINT)  0.50000002E-03
CRITICAL TIME, SEC.                                 (TCR)  0.12000001E-02

U VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
 IS SSUMED TO BE THE VALUE OF A.

U CONSTANT VALUES
  BEAM HALF WIDTH, IN                                 (B)  24.920000
  HINGE MOMENT, IN.-L                             (BIGMU)  1562.1230
  WEIGHT PER HALF AREA                                (W)  0.34721902
```

TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4-2.8 POUND AT 7 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEA4--2.8 LB. AT 7 IN. 3 27 1990 9 45 7 82

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	2.0044239	1.0438719
9.5000010	1.0326266	1.0438719

BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 9.50000 IN.

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEA4--2.8 LB. AT 7 IN. 3 27 1990 9 45 13 4

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.71334355E-02	436.94702	0.19973619	80932.406	2221.5291	78710.875	28.000000
0.99999993E-03	0.14876667E-01	430.29495	0.41654670	80932.406	4632.9639	76299.445	28.000000
0.14999997E-02	0.22501113E-01	423.64285	0.63003117	80932.406	7007.4053	73925.000	28.000000
0.19999994E-02	0.30006772E-01	416.99078	0.84018964	80932.406	9344.8535	71587.555	28.000000
0.24999997E-02	0.37397644E-01	410.33868	1.0470221	80932.406	11645.309	69287.094	28.000000
0.30000000E-02	0.44661727E-01	403.68658	1.2505283	80932.406	13908.770	67023.641	28.000000
0.35000003E-02	0.51811021E-01	397.03452	1.4507086	80932.406	16135.237	64797.168	28.000000
0.40000007E-02	0.58841530E-01	390.38242	1.6475629	80932.406	18324.713	62607.695	28.000000
0.44999998E-02	0.65753251E-01	383.73035	1.8410910	80932.406	20477.193	60455.211	28.000000
0.49999990E-02	0.72546104E-01	377.07825	2.0312932	80932.406	22592.682	58339.727	28.000000
0.54999961E-02	0.79220325E-01	370.42615	2.2181692	80932.406	24671.178	56261.227	28.000000
0.59999973E-02	0.85775688E-01	363.77408	2.4017193	80932.406	26712.680	54219.727	28.000000
0.64999964E-02	0.92212260E-01	357.12198	2.5819433	80932.406	28717.187	52215.219	28.000000
0.69999956E-02	0.98530039E-01	350.46988	2.7588410	80932.406	30684.703	50247.703	28.000000
0.74999947E-02	0.10472934	343.81781	2.9324131	80932.406	32615.225	48317.180	28.000000
0.79999939E-02	0.11080925	337.16571	3.1026590	80932.406	34508.754	46423.652	28.000000
0.84999930E-02	0.11677067	330.51361	3.2695787	80932.406	36365.289	44567.117	28.000000
0.89999922E-02	0.12261331	323.86154	3.4331727	80932.406	38184.832	42747.574	28.000000
0.94999913E-02	0.12833714	317.20944	3.5934401	80932.406	39967.379	40965.027	28.000000
0.99999905E-02	0.13394222	310.55737	3.7503819	80932.406	41712.934	39219.473	28.000000
0.10499990E-01	0.13942850	303.90527	3.9039479	80932.406	43421.496	37510.910	28.000000
0.10999989E-01	0.14479597	297.25317	4.0542070	80932.406	45093.066	35839.340	28.000000
0.11499988E-01	0.15004468	290.60110	4.2012510	80932.406	46727.641	34204.766	28.000000
0.11999987E-01	0.15517460	283.94901	4.3448887	80932.406	48325.223	32607.184	28.000000
0.12499986E-01	0.16018571	277.29694	4.4851999	80932.406	49885.812	31046.594	28.000000
0.12999985E-01	0.16507806	270.64484	4.6221057	80932.406	51409.406	29523.000	28.000000

TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4-2.8 POUND AT 7 INCHES (Continued).

0.13499985E-01	0.16305162		263.99274	4.7558451	80932.406	52896.008	28036.398	28.000000
0.13999984E-01	0.17450637		257.34067	4.8861780	80932.406	54345.617	26586.789	28.000000
0.14499983E-01	0.17904235		250.68857	5.0131860	80932.406	55758.234	25174.172	28.000000
0.14999982E-01	0.18345954		244.03698	5.1368670	80932.406	57133.855	23798.551	28.000000
0.15499981E-01	0.18775792		237.38440	5.2572217	80932.406	58472.484	22459.922	28.000000
0.15999980E-01	0.19193755		230.73230	5.3742514	80932.406	59774.121	21158.285	28.000000
0.16499979E-01	0.19599837		224.08022	5.4879541	80932.406	61038.762	19893.645	28.000000
0.16999978E-01	0.19994040		217.42819	5.5983310	80932.406	62266.410	18665.996	28.000000
0.17499977E-01	0.20376366		210.77617	5.7053823	80932.406	63457.066	17475.340	28.000000
0.17999977E-01	0.20746014		204.12415	5.8091078	80932.406	64610.730	16321.676	28.000000
0.18499976E-01	0.21105380		197.47214	5.9095063	80932.406	65727.398	15205.008	28.000000
0.18999975E-01	0.21452071		190.82011	6.0065799	80932.406	66807.078	14125.328	28.000000
0.19499974E-01	0.21786082		184.16809	6.1003270	80932.406	67849.766	13082.641	28.000000
0.19999973E-01	0.22109014		177.51607	6.1907477	80932.406	68855.461	12076.945	28.000000
0.20499973E-01	0.22420068		170.86404	6.2778430	80932.406	69824.156	11108.250	28.000000
0.20999972E-01	0.22720043		164.21202	6.3616123	80932.406	70755.859	10176.547	28.000000
0.21499971E-01	0.23007339		157.56000	6.4420547	80932.406	71650.570	9281.8359	28.000000
0.21999970E-01	0.23282757		150.90797	6.5191722	80932.406	72508.289	8424.1172	28.000000
0.22499969E-01	0.23546256		144.25595	6.5929632	80932.406	73329.016	7603.3906	28.000000
0.22999968E-01	0.23797956		137.60394	6.6634278	80932.406	74112.750	6819.6562	28.000000
0.23499968E-01	0.24037730	*	130.95192	6.7305665	80932.406	74859.492	6072.9141	28.000000

MAXIMUM DEFLECTION = 7.3750262 AT TIME = 0.33339992E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES.

```
                                                                                        PAGE  1
CALCULATIONS ON A CONCRETE BEAM                                          3  27 1990   9  45  46  65

AFESC CASEA5--2.8 LB. AT 16 IN.

INPUT VALUES

   PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                 (A)  28.000000
   BEAM OR PLATE THICKNESS, IN.                            (H)  4.8000000
   LENGTH TO WIDTH RATIO, DIMENSIONLESS                   (AR) 0.88999999
   MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED          (SMALLM) 0.89859997E-03

   POWER FROM PRESSURE-LAMBDA CURVE                       (FN)  1.1500000
   UNIFORM PRESSURE LOAD, PSI.                            (PU) 0.00000000E+00
   PRESSURE DECAY, DIMENSIONLESS                      (ALPHA)  3.8000000
   PRESSURE DURATION, SEC.                               (TAU) 0.23400001E-03

   SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                     (F)  2.0000000
   WAVE FUNCTION: 1=GENERAL, 2=SQUARE                (CURVEFN)  1.0000000
   WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN) 0.36000000E+00
   REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4            (RHOR) 0.73390000E-03

   CONCRETE COMPRESSIVE STRENGTH, PSI.              (SIGMAC)  5000.0000
   REINFORCED STEEL YIELD STRESS, PSI.              (SIGMAR)  65000.000
   REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS        (Q) 0.24999999E-02
   REINFORCING DISTANCE, IN.                            (D)  3.3000000

   DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  3.2500000
   PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLP)  5.0000000
   EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.8000000
   LENGTH OF EXPLOSIVE, IN.                          (BIGL)  5.6300001

   X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
   X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
   Y 1 OF EXPLOSIVE, IN.                              (EY1)  23.400000
   Y 2 OF EXPLOSIVE, IN.                              (EY2)  27.799999

   Z 1 OF EXPLOSIVE, IN.                              (EZ1)  16.000000
   Z 2 OF EXPLOSIVE, IN.                              (EZ2)  16.000000
   SHEAR STIRRUP REINFORCEMENT RATIO                   (Q1) 0.49999999E-04
   ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLH)  2.0000000

   TIME INCREMENT, SEC.                             (TINCR) 0.99999997E-04
   TIME MAXIMUM, SEC.                                (TMAX) 0.18000000
   TIME STEP INTERVAL PER PRINTED LINE, SEC.      (TPRINT) 0.58000002E-03
   CRITICAL TIME, SEC.                                (TCR) 0.12000001E-02

COMPUTED CONSTANT VALUES
   BEAM HALF WIDTH, IN.                                 (B)  24.920000
   HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  1562.1230
   WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W) 0.34721902
   ORIGINAL HINGE LOCATION, IN.                        (XH)  26.675293

   CLAMPED-SUPPORTED        GENERAL TIME FUNCTION        VERTICAL WALL        BLAST LOAD
```

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES (Continued).

PAGE 2

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION

3 27 1990 9 46 3 41

AFESC CASEA5--2.8 LB. AT 16 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.45104304	1.0438719

PAGE 3

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

3 27 1990 9 46 4 17

AFESC CASEA5--2.8 LB. AT 16 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	26.675293
0.49999997E-03	0.46662036E-02	27[illegible].55042	0.12597992	33701.008	1453.1716	32247.836	26.998375
0.99999933E-03	0.86243285E-02	[illegible]74.55042	0.26325515	33701.008	2397.2546	30703.754	27.353092
0.14999997E-02	0.14560942E-01	267.21716	0.40476910	33701.006	4501.9702	29199.037	28.000000
0.19999994E-02	0.19160384E-01	260.56509	0.53671479	33701.008	5969.5098	27731.498	28.000000
0.24999997E-02	0.23761937E-01	253.91299	0.66533422	33701.008	7400.0571	26300.951	28.000000
0.30000000E-02	0.28236704E-01	247.26091	0.79062772	33701.008	8793.6113	24907.396	28.000000
0.35000003E-02	0.32592684E-01	240.60863	0.91259515	33701.008	10150.172	23550.836	28.000000
0.40000007E-02	0.36829870E-01	233.95673	1.0312365	33701.008	11469.759	22231.270	28.000000
0.44999998E-02	0.40948283E-01	227.30464	1.1465520	33701.008	12752.313	20948.695	28.000000
0.49999930E-02	0.44947300E-01	220.65259	1.2585412	33701.009	13997.894	19703.113	28.000000
0.54999931E-02	0.48828732E-01	214.00058	1.3672045	33701.008	15206.460	18494.527	28.000000
0.59999973E-02	0.52590776E-01	207.[illegible]	1.4725417	33701.008	16378.075	17322.934	28.000000
0.64999964E-02	0.56234036E-01	200.[illegible]	1.5745530	33701.008	17512.670	16188.330	28.000000
0.69999956E-02	0.59758510E-01	194.04451	1.6732383	33701.008	18610.267	15090.721	28.000000
0.74999947E-02	0.63164197E-01	187.39249	1.7685975	33701.008	19670.902	14030.105	28.000000
0.79999939E-02	0.66451102E-01	180.74046	1.8606309	33701.008	20694.525	13006.482	28.000000
0.84999930E-02	0.69619216E-01	174.08844	1.9493381	33701.008	21681.156	12019.852	28.000000
0.89999922E-02	0.72668545E-01	167.43642	2.0347192	33701.008	22630.793	11070.215	28.000000
0.94999913E-02	0.75599088E-01	160.78439	2.1167746	33701.008	23543.437	10157.570	28.000000
0.99999905E-02	0.78410845E-01	154.13239	2.1955037	33701.008	24419.088	9231.9199	28.000000
0.10499990E-01	0.81103817E-01	147.48036	2.2709069	33701.008	25257.746	8443.2617	28.000000
0.10999989E-01	0.83678007E-01	140.82834	2.3429842	33701.008	26059.412	7641.5957	28.000000
0.11499998E-01	0.86133406E-01	134.17632	2.4117353	33701.008	26824.084	6876.5238	28.000000
0.11999997E-01	0.88470219E-01	127.52429	2.4771605	33701.008	27551.764	6149.2441	28.000000
0.12499996E-01	0.90687949E-01	120.87227	2.5392597	33701.008	28242.451	5458.5566	28.000000
0.12999995E-01	0.92786086E-01	114.22025	2.5980327	33701.008	28896.145	4804.8633	28.000000
0.13499995E-01	0.94767196E-01	107.56823	2.6534801	33701.008	29512.846	4188.1621	28.000000
0.13999994E-01	0.96628614E-01	100.91621	2.7056012	33701.008	30092.553	3608.4551	28.000000
0.14499993E-01	0.98371290E-01	94.264191	2.7543962	33701.008	30635.268	3065.7402	28.000000
0.14999992E-01	0.99995188E-01	87.612167	2.7998652	33701.008	31140.990	2560.0176	28.000000
0.15499991E-01	0.10150030	80.960144	2.8420084	33701.008	31609.719	2091.7891	28.000000
0.15999990E-01	0.10288662	74.308121	2.8808253	33701.008	32041.455	1659.5527	28.000000

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES (Continued).

0.16499977E-01	0.10415415	67.656097	2.9183163	33701.008	32436.197	1264.8105	28.000000
0.16999979E-01	0.10530291	61.004082	2.9464813	33701.008	32793.949	907.05859	28.000000
0.17499978E-01	0.10633287	54.352058	2.9773202	33701.008	33114.707	586.30078	28.000000
0.17999977E-01	0.10724405	47.700035	3.0028334	33701.008	33398.473	302.53516	28.000000
0.18499976E-01	0.10803644	41.048016	3.0250204	33701.008	33645.242	55.765625	28.000000
0.18999975E-01	0.10871005	34.395996	3.0438014	33701.008	33855.020	-154.01172	28.000000
0.19499974E-01	0.10926487	27.743971	3.0594165	33701.008	34027.805	-326.79687	28.000000
0.19999973E-01	0.10970090	21.091942	3.0716252	33701.008	34163.598	-462.58984	28.000000
0.20499973E-01	0.11001816	14.439912	3.0805085	33701.008	34262.398	-561.39062	28.000000
0.20999972E-01	0.11021662	7.7878061	3.0860653	33701.008	34324.203	-623.19531	28.000000
0.21499971E-01	0.11029629	1.1358584	3.0882962	33701.008	34349.016	-648.00781	28.000000

MAXIMUM DEFLECTION = 3.0883434 AT TIME = 0.21599971E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES.

CALCULATIONS ON A CONCRETE BEAM — PAGE 1

AFESC CASEA6--2.8 LB. AT 23 IN. — 3 27 1990 9 46 43 72

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN.	(A)	28.000000
BEAM OR PLATE THICKNESS, IN.	(H)	4.0000000
LENGTH TO WIDTH RATIO, DIMENSIONLESS	(AR)	0.88999999
MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED	(SMALLM)	0.89859997E-03
POWER FROM PRESSURE-LAMBDA CURVE	(FN)	1.2500000
UNIFORM PRESSURE LOAD, PSI.	(PU)	0.00000000E+00
PRESSURE DECAY, DIMENSIONLESS	(ALFHA)	5.4000001
PRESSURE DURATION, SEC.	(TAU)	0.37299999E-03
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED	(F)	2.0000000
WAVE FUNCTION: 1=GENERAL, 2=SQUARE	(WAVEFN)	1.9000000
WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB	(SMALLN)	0.00000000E+00
REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4	(RHOR)	0.73390000E-03
CONCRETE COMPRESSIVE STRENGTH, PSI.	(SIGMAC)	5000.0000
REINFORCED STEEL YIELD STRESS, PSI.	(SIGMAR)	65000.000
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS	(Q)	0.24999999E-02
REINFORCING DISTANCE, IN.	(D)	3.3000000
DIAMETER OF EXPLOSIVE, IN.	(BIGD)	3.2500000
PRESSURE INTERCEPT ON P-LAMBDA CURVE	(SMALLK)	5.8000000
EXPLOSIVE WEIGHT, LBS.	(BIGW)	2.8000000
LENGTH OF EXPLOSIVE, IN.	(BIGL)	5.6300001
X 1 OF EXPLOSIVE, IN.	(EX1)	28.000000
X 2 OF EXPLOSIVE, IN.	(EX2)	28.000000
Y 1 OF EXPLOSIVE, IN.	(EY1)	23.400000
Y 2 OF EXPLOSIVE, IN.	(EY2)	27.799999
Z 1 OF EXPLOSIVE, IN.	(EZ1)	23.000000
Z 2 OF EXPLOSIVE, IN.	(EZ2)	23.000000
SHEAR STIRRUP REINFORCEMENT RATIO	(Q1)	0.49999999E-04
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR	(SMALLH)	2.0000000
TIME INCREMENT, SEC.	(TINC)	0.99999997E-04
TIME MAXIMUM, SEC.	(TMAX)	0.10000000
TIME STEP INTERVAL PER PRINTED LINE, SEC.	(TPRINT)	0.50000002E-03
CRITICAL TIME, SEC.	(TCR)	0.12000001E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN.	(B)	24.920000
HINGE MOMENT, IN.-LBS./IN.	(BIGMU)	1562.1230
WEIGHT PER UNIT AREA, LBS./IN.SQ.	(W)	0.34721902
ORIGINAL HINGE LOCATION, IN.	(XH)	20.732651

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TABLE I-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES (Continued).

PAGE 2

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION

AFESC CASEA6--2.8 LB. AT 23 IN.   3 27 1990   9 46 52 29

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.24826905	1.0438719

PAGE 3

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

AFESC CASEA6--2.8 LB. AT 23 IN.   3 27 1990   9 46 52 73

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	20.732651
0.49999997E-03	0.37507324E-02	179.42178	0.80153294E-01	20190.209	1168.0712	19022.139	21.370037
0.99999993E-03	0.76976208E-02	179.42178	0.16986418	20190.209	2397.2327	17792.977	22.067078
0.14999997E-02	0.11401623E-01	179.42178	0.25957507	20190.209	3550.7485	16639.461	22.766500
0.19999994E-02	0.14884433E-01	179.42178	0.34928602	20190.209	4635.3013	15554.828	23.466532
0.24999997E-02	0.18165275E-01	179.42178	0.43899697	20190.209	5657.1167	14533.092	24.166822
0.30000000E-02	0.21261213E-01	179.42178	0.52870792	20190.209	6621.2686	13568.940	24.867250
0.35000002E-02	0.24107442E-01	179.42178	0.61841887	20190.209	7532.5698	12657.639	25.567766
0.40000007E-02	0.26957544E-01	179.42178	0.70812982	20190.209	8395.2471	11794.962	26.268337
0.44999998E-02	0.29506981E-01	179.42178	0.79784077	20190.209	9213.0908	10977.118	26.968948
0.49999990E-02	0.32076903E-01	156.13680	0.89815331	20190.209	9989.5420	10200.667	28.000000
0.54999981E-02	0.34448523E-01	129.42477	0.96455866	20190.209	10728.124	9462.0850	28.000000
0.59999973E-02	0.36701359E-01	122.83276	1.0276381	20190.209	11425.713	8760.4961	28.000000
0.64999964E-02	0.38835402E-01	116.18074	1.0877919	20190.209	12094.309	8095.9004	28.000000
0.69999956E-02	0.40859673E-01	109.52872	1.1403103	20190.209	12721.912	7468.2969	28.000000
0.74999947E-02	0.42747147E-01	102.87665	1.1969202	20190.209	13312.521	6877.6875	28.000000
0.79999939E-02	0.44524837E-01	96.224670	1.2466954	20190.209	13866.139	6324.0703	28.000000
0.84999930E-02	0.46183743E-01	89.572647	1.2931448	20190.209	14382.763	5807.4463	28.000000
0.89999922E-02	0.47723960E-01	82.920631	1.3362681	20190.209	14862.394	5327.8154	28.000000
0.94999913E-02	0.49145152E-01	76.268608	1.3760654	20190.209	15305.032	4885.1768	28.000000
0.99999905E-02	0.50447736E-01	69.616585	1.4125366	20190.209	15710.678	4479.5312	28.000000
0.10499990E-01	0.51631493E-01	62.964565	1.4456819	20190.209	16079.330	4110.8789	28.000000
0.10999989E-01	0.52696470E-01	56.312546	1.4755012	20190.209	16410.990	3779.2187	28.000000
0.11499988E-01	0.53642650E-01	49.660522	1.5019945	20190.209	16705.656	3484.5527	28.000000
0.11999987E-01	0.54470062E-01	43.008499	1.5251617	20190.209	16963.330	3226.8789	28.000000
0.12499986E-01	0.55178458E-01	36.356480	1.5450031	20190.209	17184.010	3006.1992	28.000000
0.12999985E-01	0.55768508E-01	29.704458	1.5615182	20190.209	17367.697	2822.5117	28.000000
0.13499985E-01	0.56239553E-01	23.052429	1.5747075	20190.209	17514.393	2675.8164	28.000000
0.13999984E-01	0.56591813E-01	16.400400	1.5845709	20190.209	17624.094	2566.1152	28.000000
0.14499983E-01	0.56825280E-01	9.7483740	1.5911078	20190.209	17696.803	2493.4062	28.000000
0.14999982E-01	0.56939367E-01	3.0963471	1.5943191	20190.209	17732.520	2457.6895	28.000000

MAXIMUM DEFLECTION = 1.5946493   AT TIME = 0.15299981E-01

TABLE I-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES (Continued).

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

TABLE I-7. CALCULATIONS ON A CONCRETE BEAM, AFESC CASE B1-2.4 POUND AT 6 INCHES.

TABLE I-7. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB1-2.4 POUND AT 6 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEB1-2.4 LB. AT 6 IN. 3 27 1990 9 50 2 72

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I ARK	I CRITICAL
1.0000000	2.5652019	1.7530495
6.6999993	1.7429360	1.7530495

BREACH OR LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 6.70000 IN.

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEB1-2.4 LB. AT 6 IN. 3 27 1990 9 50 11 67

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.85131181E-02	483.20015	0.22543691	105317.59	9441.2945	95876.205	28.000000
0.99999993E-03	0.11456335E-01	458.16061	0.46077907	105317.59	19297.422	86029.164	28.000000
0.14999997E-02	0.24414197E-01	433.11304	0.68359751	105317.59	28629.053	76680.531	28.000000
0.19999994E-02	0.31924717E-01	408.06546	0.89389205	105317.59	37436.191	67881.391	28.000000
0.24999997E-02	0.38987961E-01	383.01700	1.0916629	105317.59	45718.820	59598.758	28.000000
0.30000001E-02	0.45603927E-01	357.97034	1.2769099	105317.59	53476.973	51840.613	28.000000
0.35000003E-02	0.51772617E-01	332.92276	1.4498332	105317.59	60710.621	44606.965	28.000000
0.40000007E-02	0.57494026E-01	307.87518	[illegible]	105317.59	67419.766	37897.820	28.000000
0.44999998E-02	0.62768154E-01	282.82764	[illegible]	105317.59	73[illegible].422	31713.164	28.000000
0.49999990E-02	0.67595005E-01	257.78006	1.8926601	105317.59	79264.586	26053.000	28.000000
0.54999981E-02	0.71974533E-01	232.73248	2.0152884	105317.59	84400.250	20917.336	28.000000
0.59999973E-02	0.75908880E-01	207.68491	2.1253927	105317.59	89011.414	16306.172	28.000000
0.64999964E-02	0.79391904E-01	182.63734	2.2229735	105317.59	93098.086	12219.500	28.000000
0.69999956E-02	0.82426640E-01	157.58978	2.3080299	105317.59	96660.266	8657.3203	28.000000
0.74999947E-02	0.85020110E-01	132.54221	2.3805630	105317.59	99697.945	5619.6406	28.000000
0.79999939E-02	0.87163232E-01	107.49464	2.4405723	105317.59	102211.13	3106.4531	28.000000
0.84999930E-02	0.88859200E-01	82.447067	2.4880576	105317.59	104199.02	1117.7656	28.000000
0.89999922E-02	0.90107826E-01	57.399498	2.5230193	105317.59	105664.02	-346.42969	28.000000
0.94999913E-02	0.90909183E-01	32.351944	2.5454571	105317.59	106603.71	-1286.1250	28.000000
0.99999905E-02	0.91253257E-01	7.3043928	2.5553713	105317.59	107018.91	-1701.3281	28.000000

MAXIMUM DEFLECTION = 2.5558302 AT TIME = 0.10199990E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-8. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB2-2.4 POUND AT 12 INCHES.

```
 CALCULATIONS ON A CONCRETE BEAM                                                                          PAGE  1

 AFESC CASEB2--2.4 LB. AT 12 IN.                                                      3  27 1990     9   51   59   54

INPUT VALUES

    PLATE HALF WIDTH OR BEAM HALF SPAN, IN.            (A)  28.000000
    BEAM OR PLATE THICKNESS, IN.                       (H)  4.0000000
    LENGTH TO WIDTH RATIO, DIMENSIONLESS              (AR) 0.88999999
    MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED      (SMALLM) 0.89059997E-03

    POWER FROM PRESSURE-LAMBDA CURVE                  (FN)  1.0000000
    UNIFORM PRESSURE LOAD, PSI.                       (PU) 0.00000000E+00
    PRESSURE DECAY, DIMENSIONLESS                  (ALPHA)  3.5000000
    PRESSURE DURATION, SEC.                          (TAU) 0.20200000E-03

    SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                (F)  2.0000000
    WAVE FUNCTION: 1=GENERAL, 2=SQUARE            (WAVEFN)  1.0000000
    WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLW) 0.00000000E+00
    REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4       (RHOR) 0.73390000E-03

    CONCRETE COMPRESSIVE STRENGTH, PSI.          (SIGMAC)  5000.0000
    REINFORCED STEEL YIELD STRESS, PSI.          (SIGMAR)  65000.000
    REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS    (Q) 0.99999998E-02
    REINFORCING DISTANCE, IN.                        (D)  3.3000000

    DIAMETER OF EXPLOSIVE, IN.                    (BIGD)  2.5000000
    PRESSURE INTERCEPT ON P-LAMBDA CURVE        (SMALLK)  5.0000000
    EXPLOSIVE WEIGHT, LBS.                        (BIGW)  2.4000001
    LENGTH OF EXPLOSIVE, IN.                      (BIGL)  8.1499996

    X 1 OF EXPLOSIVE, IN.                          (EX1)  28.000000
    X 2 OF EXPLOSIVE, IN.                          (EX2)  28.000000
    Y 1 OF EXPLOSIVE, IN.                          (EY1)  20.900000
    Y 2 OF EXPLOSIVE, IN.                          (EY2)  29.100000

    Z 1 OF EXPLOSIVE, IN.                          (EZ1)  12.000000
    Z 2 OF EXPLOSIVE, IN.                          (EZ2)  12.000000
    SHEAR STIRRUP REINFORMENT RATIO                 (Q1) 0.49999999E-04
    ENVIRONMENT FACTOR: 1=SOIL, 2=AIR           (SMALLA)  2.0000000

    TIME INCREMENT, SEC.                         (TINCR) 0.99999997E-04
    TIME MAXIMUM, SEC.                            (TMAX) 0.10000000
    TIME STEP INTERVAL PER PRINTED LINE, SEC.  (TPRINT) 0.50000002E-03
    CRITICAL TIME, SEC.                            (TCR) 0.14000000E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (O,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
    BEAM HALF WIDTH, IN.                               (B)  24.920000
    HINGE MOMENT, IN.-LBS./IN.                    (BIGMU)  5802.0205
    WEIGHT PER UNIT AREA, LBS./IN.SQ.                  (W) 0.34721902
```

TABLE I-8. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB2-2.4 POUND AT 12 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEB2--2.4 LB. AT 12 IN. 3 27 1990 9 52 2 67

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.73421699	1.7538495

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEB2--2.4 LB. AT 12 IN. 3 27 1990 9 52 3 17

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.54180268E-02	315.97366	0.15170476	46473.320	6353.3926	40119.930	28.000000
0.99999993E-03	0.10836774E-01	290.92609	0.30342969	46473.320	12707.631	33765.687	28.000000
0.14999997E-02	0.15808245E-01	265.87854	0.44263086	46473.320	18537.373	27935.947	28.000000
0.19999994E-02	0.20332437E-01	240.83096	0.56930822	46473.320	23842.621	22630.699	28.000000
0.24999997E-02	0.24409352E-01	215.78339	0.68346184	46473.320	28623.373	17849.947	28.000000
0.30000000E-02	0.28038988E-01	190.73582	0.78509164	46473.320	32879.629	13593.691	28.000000
0.35000003E-02	0.31221347E-01	165.68825	0.87419772	46473.320	36611.387	9861.9356	28.000000
0.40000007E-02	0.33956425E-01	140.64069	0.95077986	46473.320	39818.652	6654.6680	28.000000
0.44999998E-02	0.36244225E-01	115.59311	1.0148383	46473.320	42501.422	3971.8984	28.000000
0.49999990E-02	0.38084749E-01	90.545547	1.0663730	46473.320	44659.691	1813.6289	28.000000
0.54999981E-02	0.39477997E-01	65.497971	1.1053839	46473.320	46293.465	179.85547	28.000000
0.59999973E-02	0.40423963E-01	40.450417	1.1318710	46473.320	47402.742	-929.42187	28.000000
0.64999964E-02	0.40922653E-01	15.402866	1.1458343	46473.320	47987.527	-1514.2070	28.000000

MAXIMUM DEFLECTION = 1.1479878 AT TIME = 0.68999957E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-9. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB3-2.4 POUND AT 18 INCHES.

```
     CALCULATIONS ON A CONCRETE BEAM                                                                  PAGE  1
    AFESC CASEB3--2.4 LB. AT 18 IN.                                                  3  27 1990    9  52   9  92

 INPUT VALUES

     PLATE HALF WIDTH OR BEAM HALF SPAN, IN.              (H)  28.000000
     BEAM OR PLATE THICKNESS, IN.                         (H)  4.0000000
     LENGTH TO WIDTH RATIO, DIMENSIONLESS                (AR) 0.88999939
     MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED        (SMALLM) 0.89859997E-03

     POWER FROM PRESSURE-LAMBDA CURVE                    (FN)  1.1500000
     UNIFORM PRESSURE LOAD, PSI.                         (PU) 0.00000000E+00
     PRESSURE DECAY, DIMENSIONLESS                    (ALPHA)  4.3000002
     PRESSURE DURATION, SEC.                            (TAU) 0.26199999E-03

     SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                  (F)  2.0000000
     WAVE FUNCTION: 1=GENERAL, 2=SQUARE               (WAVEFN)  1.0000000
     WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN) 0.00000000E+00
     REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4         (RHOR) 0.73390000E-03

     CONCRETE COMPRESSIVE STRENGTH, PSI.             (SIGMAC)  5000.0000
     REINFORCED STEEL YIELD STRESS, PSI.             (SIGMAR)  65000.000
     REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS        (U) 0.99999398E-02
     REINFORCING DISTANCE, IN.                            (D)  3.3000000

     DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  2.5000000
     PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLK)  5.0000000
     EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.4000001
     LENGTH OF EXPLOSIVE, IN.                          (BIGL)  8.1499996

     X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
     X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
     Y 1 OF EXPLOSIVE, IN.                              (EY1)  20.900000
     Y 2 OF EXPLOSIVE, IN.                              (EY2)  23.100000

     Z 1 OF EXPLOSIVE, IN.                              (EZ1)  18.000000
     Z 2 OF EXPLOSIVE, IN.                              (EZ2)  18.000000
     SHEAR STIRRUP REINFORCEMENT RATIO                   (Q1) 0.49999999E-04
     ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLH)  2.0000000

     TIME INCREMENT, SEC.                             (TINCR) 0.99999997E-04
     TIME MAXIMUM, SEC.                                (TMAX) 0.10000000
     TIME STEP INTERVAL PER PRINTED LINE, SEC.       (TPRINT) 0.50000002E-03
     CRITICAL TIME, SEC.                                (TCR) 0.14000000E-02

 COMPUTED CONSTANT VALUES
     BEAM HALF WIDTH, IN.                                 (B)  24.920000
     HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  5882.0205
     WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W) 0.34721902
     ORIGINAL HINGE LOCATION, IN.                        (XH)  26.098931

     CLAMPED-SUPPORTED         GENERAL TIME FUNCTION          VERTICAL WALL              BLAST LOAD
```

TABLE I-9. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB3-2.4 POUND AT 18 INCHES (Continued).

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION   PAGE 2

AFESC CASEB3—2.4 LB. AT 18 IN.   3 27 1990   9 52 18 60

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.35309106	1.7538495

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE   PAGE 3

AFESC CASEB3—2.4 LB. AT 18 IN.   3 27 1990   9 52 19 10

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	26.098991
0.49999997E-03	0.30596147E-02	232.74945	0.10639135	25169.121	4525.9375	20643.184	28.000000
0.99999993E-03	0.71336022E-02	198.81953	0.21374086	25169.121	8951.4648	16217.656	28.000000
0.14999997E-02	0.10960312E-01	173.77196	0.30688873	25169.121	12852.497	12316.624	28.000000
0.19999994E-02	0.13839743E-01	148.72440	0.38751280	25169.121	16229.033	8940.0879	28.000000
0.24999997E-02	0.16271897E-01	123.67682	0.45561311	25169.121	19081.074	6088.0469	28.000000
0.30000000E-02	0.18256772E-01	98.629257	0.51118964	25169.121	21408.617	3760.5039	28.000000
0.35000003E-02	0.19794371E-01	73.581680	0.55424237	25169.121	23211.664	1957.4570	28.000000
0.40000007E-02	0.20884631E-01	48.534122	0.58477134	25169.121	24490.215	678.90625	28.000000
0.44999998E-02	0.21527734E-01	23.486568	0.60277653	25169.121	25244.271	-75.150391	28.000000

MAXIMUM DEFLECTION = 0.60825795   AT TIME = 0.49999990E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-10. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB41-2.8 POUND AT 7 INCHES.

PAGE 1

3 27 1990 9 54 36 8

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEB4--2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN.	(A)	28.000000
BEAM OR PLATE THICKNESS, IN.	(H)	4.0000000
LENGTH TO WIDTH RATIO, DIMENSIONLESS	(AR)	0.88999999
MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED	(SMALLM)	0.89859997E-03
POWER FROM PRESSURE-LAMBDA CURVE	(FN)	1.0000000
UNIFORM PRESSURE LOAD, PSI.	(PU)	0.00000000E+00
PRESSURE DECAY, DIMENSIONLESS	(ALPHA)	3.4000001
PRESSURE DURATION, SEC.	(TAU)	0.24500000E-03
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED	(F)	2.0000000
WAVE FUNCTION: 1=GENERAL, 2=SQUARE	(WAVEFN)	1.0000000
WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB	(SMALLN)	0.00000000E+00
REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4	(RHOR)	0.73390000E-03
CONCRETE COMPRESSIVE STRENGTH, PSI.	(SIGMAC)	5000.0000
REINFORCED STEEL YIELD STRESS, PSI.	(SIGMAR)	65000.000
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS	(W)	0.99999998E-02
REINFORCING DISTANCE, IN.	(D)	3.3000000
DIAMETER OF EXPLOSIVE, IN.	(BIGD)	3.2500000
PRESSURE INTERCEPT ON P-LAMBDA CURVE	(SMALLB)	5.0000000
EXPLOSIVE WEIGHT, LBS.	(BIGW)	2.8000000
LENGTH OF EXPLOSIVE, IN.	(BIGL)	5.6300001
X 1 OF EXPLOSIVE, IN.	(EX1)	28.000000
X 2 OF EXPLOSIVE, IN.	(EX2)	28.000000
Y 1 OF EXPLOSIVE, IN.	(EY1)	23.400000
Y 2 OF EXPLOSIVE, IN.	(EY2)	27.799999
Z 1 OF EXPLOSIVE, IN.	(EZ1)	7.0000000
Z 2 OF EXPLOSIVE, IN.	(EZ2)	7.0000000
SHEAR STIRRUP REINFORMENT RATIO	(Q1)	0.49999999E-04
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR	(SMALLA)	2.0000000
TIME INCREMENT, SEC.	(TINCR)	0.99999997E-04
TIME MAXIMUM, SEC.	(TMAX)	0.10000000
TIME STEP INTERVAL PER PRINTED LINE, SEC.	(TPRINT)	0.50000002E-03
CRITICAL TIME, SEC.	(TCR)	0.14000000E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN.	(B)	24.920000
HINGE MOMENT, IN.-LBS./IN.	(BIGMU)	5882.0205
WEIGHT PER UNIT AREA, LBS./IN.SQ.	(W)	0.34721902

TABLE I-10. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB41-2.8 POUND AT 7 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEB4--2.8 LB. AT 7 IN. 3 27 1990 9 54 39 76

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	1.9971284	1.7538495
4.2999992	1.7475601	1.7538495

BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 4.30000 IN.

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEB4--2.8 LB. AT 7 IN. 3 27 1990 9 54 46 63

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.53651888E-02	418.55151	0.19513729	80304.945	8172.3472	72132.602	28.000000
0.99999993E-03	0.14219683E-01	393.50394	0.39815110	80304.945	16674.564	63630.383	28.000000
0.14999997E-02	0.21022901E-01	368.45636	0.58064123	80304.945	24652.285	55652.660	28.000000
0.19999994E-02	0.27378840E-01	343.40876	0.76660752	80304.945	32105.512	48199.434	28.000000
0.24999997E-02	0.33287503E-01	318.36124	0.93205011	80304.945	39034.242	41270.703	28.000000
0.30000000E-02	0.38748886E-01	293.31366	1.0849688	80304.945	45138.477	34866.469	28.000000
0.35000003E-02	0.43762989E-01	268.26608	1.2255637	80304.945	51318.215	28986.730	28.000000
0.40000007E-02	0.48329815E-01	243.21852	1.353[illegible]348	80304.945	56673.457	23631.488	28.000000
0.44999998E-02	0.52449364E-01	218.17094	1.4685[illegible]2	80304.945	61504.203	18800.742	28.000000
0.49999990E-02	0.56121636E-01	193.12338	1.5714058	80304.945	65810.453	14494.492	28.000000
0.54999981E-02	0.59346627E-01	168.07581	1.6617056	80304.945	69592.203	10712.742	28.000000
0.59999973E-02	0.62124342E-01	143.02824	1.7394816	80304.945	72849.461	7455.4844	28.000000
0.64999964E-02	0.64454779E-01	117.98067	1.8047338	80304.94[illegible]	75582.227	4722.7187	28.000000
0.69999956E-02	0.66337936E-01	92.933105	1.8574622	80304.945	77790.492	2514.4531	28.000000
0.74999947E-02	0.67773819E-01	67.885529	1.8976669	80304.945	79474.266	830.67969	28.000000
0.79999933E-02	0.68762422E-01	42.837975	1.9253478	80304.945	80633.539	-328.59375	28.000000
0.84999930E-02	0.69303744E-01	17.790421	1.9405048	80304.945	81268.320	-963.37500	28.000000

MAXIMUM DEFLECTION = 1.9436134 AT TIME = 0.88999923E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-11. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB4-2.8 POUND AT 7 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                          PAGE 1

AFESC CASEB4--2.8 LB. AT 7 IN.                                          5  29 1990    2  22  27  83

INPUT VALUES

    PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                 (A)  28.000000
    BEAM OR PLATE THICKNESS, IN.                            (H)  4.0000000
    LENGTH TO WIDTH RATIO, DIMENSIONLESS                   (AR)  0.88999993
    MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED          (SMALLM)  0.89851997E-03

    POWER FROM PRESSURE-LAMBDA CURVE                       (FN)  1.0000000
    UNIFORM PRESSURE LOAD, PSI.                            (PU)  0.00000000E+00
    PRESSURE DECAY, DIMENSIONLESS                       (ALFHA)  3.4000001
    PRESSURE DURATION, SEC.                               (TAU)  0.24500000E-03

    SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                     (F)  2.0000000
    WAVE FUNCTION: 1=GENERAL, 2=SQUARE                  (WAVEFN)  1.0000000
    WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
    REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4            (RHOR)  0.73390000E-03

    CONCRETE COMPRESSIVE STRENGTH, PSI.               (SIGMAC)  5000.0000
    REINFORCED STEEL YIELD STRESS, PSI.               (SIGMAR)  65000.000
    REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS          (Q)  0.99999998E-02
    REINFORCING DISTANCE, IN.                              (D)  3.3000000

    DIAMETER OF EXPLOSIVE, IN.                          (BIGD)  4.4600000
    PRESSURE INTERCEPT ON P-LAMBDA CURVE              (SMALLK)  5.0000000
    EXPLOSIVE WEIGHT, LBS.                              (BIGW)  2.8000000
    LENGTH OF EXPLOSIVE, IN.                            (BIGL)  4.4600000

    X 1 OF EXPLOSIVE, IN.                                (EX1)  28.000000
    X 2 OF EXPLOSIVE, IN.                                (EX2)  28.000000
    Y 1 OF EXPLOSIVE, IN.                                (EY1)  25.000000
    Y 2 OF EXPLOSIVE, IN.                                (EY2)  25.000000

    Z 1 OF EXPLOSIVE, IN.                                (EZ1)  7.0000000
    Z 2 OF EXPLOSIVE, IN.                                (EZ2)  7.0000000
    SHEAR STIRRUP REINFORMENT RATIO                      (QT)  0.99999999E-04
    ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                 (SMALLA)  2.0000000

    TIME INCREMENT, SEC.                               (TINCR)  0.99999997E-04
    TIME MAXIMUM, SEC.                                  (TMAX)  0.10000000
    TIME STEP INTERVAL PER PRINTED LINE, SEC.         (TPRINT)  0.50000002E-03
    CRITICAL TIME, SEC.                                  (TCR)  0.14000000E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
    BEAM HALF WIDTH, IN.                                   (B)  24.920000
    HINGE MOMENT, IN.-LBS./IN.                         (BIGMO)  5882.0205
    WEIGHT PER UNIT AREA, LBS./IN.SQ.                      (W)  0.34721402
    ORIGINAL HINGE LOCATION, IN.                          (XH)  28.000000

    CLAMPED-SUPPORTED         GENERAL TIME FUNCTION         VERTICAL WALL         BLAST LOAD
```

TABLE I-11. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB4-2.8 POUND AT 7 INCHES (Continued).

PAGE 2

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION

5 29 1990 2 22 28 71

AFESC CASEB4--2.8 LB. AT 7 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	1.4626355	1.7538495

PAGE 3

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

5 29 1990 2 22 28 82

AFESC CASEB4--2.8 LB. AT 7 IN.

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.54084929E-02	322.29959	0.15143780	49091.484	6342.2129	42749.273	28.000000
0.99999993E-03	0.10940203E-01	297.25201	0.30632567	49091.484	12828.916	36262.570	28.000000
0.14999997E-02	0.16024634E-01	272.20444	0.44868976	49091.484	18791.123	30300.361	28.000000
0.19999994E-02	0.20661786E-01	247.15680	0.57853007	49091.484	24228.834	24862.650	28.000000
0.24999997E-02	0.24851665E-01	222.10930	0.69584662	49091.484	29142.051	19949.434	28.000000
0.30000000E-02	0.28594263E-01	197.06174	0.80063939	49091.484	33530.770	15560.715	28.000000
0.35000003E-02	0.31889584E-01	172.01416	0.89290833	49091.484	37394.992	11696.492	28.000000
0.40000007E-02	0.34737628E-01	146.96660	0.97265357	49091.484	40734.719	8356.7656	28.000000
0.44999998E-02	0.37138391E-01	121.91902	1.0398749	49091.484	43549.953	5541.5312	28.000000
0.49999990E-02	0.39091878E-01	96.871460	1.0945725	49091.484	45840.691	3250.7930	28.000000
0.54999981E-02	0.40598087E-01	71.823883	1.1367464	49091.484	47606.930	1484.5547	28.000000
0.59999973E-02	0.41657019E-01	46.776325	1.1663965	49091.484	48848.672	242.81250	28.000000
0.64999964E-02	0.42268671E-01	21.728771	1.1835228	49091.484	49565.918	-474.43359	28.000000

MAXIMUM DEFLECTION = 1.1881253 AT TIME = 0.69999956F-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-12. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB5-2.8 POUND AT 16 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM 3 27 1990 9 56 21 87

AFESC CASEB5--2.8 LB. AT 16 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN.	(A)	28.000000
BEAM OR PLATE THICKNESS, IN.	(H)	4.0000000
LENGTH TO WIDTH RATIO, DIMENSIONLESS	(AK)	0.80999999
MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED	(SMALLM)	0.89859937E-03
POWER FROM PRESSURE-LAMBDA CURVE	(FN)	1.1500000
UNIFORM PRESSURE LOAD, PSI.	(PU)	0.00000000E+00
PRESSURE DECAY, DIMENSIONLESS	(ALPHA)	3.8000000
PRESSURE DURATION, SEC.	(TAU)	0.23400001E-03
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED	(F)	2.0000000
WAVE FUNCTION: 1=GENERAL, 2=SQUARE	(WAVEFN)	1.0000000
WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB	(SMALLN)	0.00000000E+00
REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4	(RHOR)	0.73390000E-03
CONCRETE COMPRESSIVE STRENGTH, PSI.	(SIGMAC)	5000.0000
REINFORCED STEEL YIELD STRESS, PSI.	(SIGMAR)	65000.000
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS	(Q)	0.99999998E-02
REINFORCING DISTANCE, IN.	(D)	3.3000000
DIAMETER OF EXPLOSIVE, IN.	(BIGD)	3.2500000
PRESSURE INTERCEPT ON P-LAMBDA CURVE	(SMALLK)	5.0000000
EXPLOSIVE WEIGHT, LBS.	(BIGW)	2.8000000
LENGTH OF EXPLOSIVE, IN.	(BIGL)	5.6300001
X 1 OF EXPLOSIVE, IN.	(EX1)	28.000000
X 2 OF EXPLOSIVE, IN.	(EX2)	28.000000
Y 1 OF EXPLOSIVE, IN.	(EY1)	23.400000
Y 2 OF EXPLOSIVE, IN.	(EY2)	27.799999
Z 1 OF EXPLOSIVE, IN.	(EZ1)	16.000000
Z 2 OF EXPLOSIVE, IN.	(EZ2)	16.000000
SHEAR STIRRUP REINFORMENT RATIO	(Q1)	0.49999999E-04
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR	(SMALLA)	2.0000000
TIME INCREMENT, SEC.	(TINCR)	0.99999997E-04
TIME MAXIMUM, SEC.	(TMAX)	0.10000000
TIME STEP INTERVAL PER PRINTED LINE, SEC.	(TPRINT)	0.50000002E-03
CRITICAL TIME, SEC.	(TCR)	0.14000000E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN.	(B)	24.920000
HINGE MOMENT, IN.-LBS./IN.	(BIGMU)	5882.0205
WEIGHT PER UNIT AREA, LBS./IN.SQ.	(W)	0.34721902
ORIGINAL HINGE LOCATION, IN.	(XH)	26.870836

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TABLE I-12. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB5-2.8 POUND AT 16 INCHES (Continued).

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION   PAGE 2

AFESC CASEB5--2.8 LB. AT 16 IN.   3 27 1990   9 56 28 73

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.44985521	1.7538495

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE   PAGE 3

AFESC CASEB5--2.8 LB. AT 16 IN.   3 27 1990   9 56 29 12

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	26.870836
0.49999997E-03	0.44909758E-02	262.37720	0.12574732	33328.793	5266.2959	28062.496	28.000000
0.99999993E-03	0.88526437E-02	237.32962	0.25067401	33328.793	10498.225	22830.568	28.000000
0.14999997E-02	0.12967034E-01	212.28206	0.36307696	33328.793	15205.658	18123.135	28.000000
0.19999994E-02	0.16534146E-01	187.23448	0.46295607	33328.793	19388.594	13940.199	28.000000
0.24999997E-02	0.19653980E-01	162.18692	0.55031145	33328.793	23047.035	10281.758	28.000000
0.30000000E-02	0.22326536E-01	137.13934	0.62514305	33328.793	[illegible]180.980	7147.8125	28.000000
0.35000003E-02	0.24551814E-01	112.09178	0.68745083	33328.793	28790.430	4538.3633	28.000000
0.40000007E-02	0.26329815E-01	87.044205	0.73723483	33328.793	30875.385	2453.4082	28.000000
0.44999993E-02	0.27660538E-01	61.996639	0.77449507	33328.793	32435.940	892.95312	28.000000
0.49999990E-02	0.28543983E-01	36.949081	0.79923153	33328.793	33471.801	-143.00781	28.000000
0.54999981E-02	0.28980149E-01	11.901531	0.81144416	33328.793	33983.266	-654.47266	28.000000

MAXIMUM DEFLECTION = 0.81276035 AT TIME = 0.57999976E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-13. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB6-2.8 POUND AT 23 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                                      PAGE  1

AFESC CASEB6--2.8 LB. AT 23 IN.                                                   3  27 1990      9   56   52   68

INPUT VALUES

     PLATE HALF WIDTH OR BEAM HALF SPAN, IN.              (A)  28.000000
     BEAM OR PLATE THICKNESS, IN.                         (H)  4.0000000
     LENGTH TO WIDTH RATIO, DIMENSIONLESS                (AR) 0.80999999
     MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED        (SMALLM) 0.89659997E-03

     POWER FROM PRESSURE-LAMBDA CURVE                    (FN)  1.2500000
     UNIFORM PRESSURE LOAD, PSI.                         (PU) 0.00000000E+00
     PRESSURE DECAY, DIMENSIONLESS                    (ALPHA)  5.4000001
     PRESSURE DURATION, SEC.                            (TAU) 0.37299999E-03

     SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                  (F)  2.0000000
     WAVE FUNCTION: 1=GENERAL, 2=SQUARE              (WAVEFN)  1.0000000
     WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLW) 0.00000000E+00
     REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4         (RHOR) 0.73390000E-03

     CONCRETE COMPRESSIVE STRENGTH, PSI.             (SIGMAC)  5000.0000
     REINFORCED STEEL YIELD STRESS, PSI.             (SIGMAR)  65000.000
     REINFORCEMENT RATIO IN TENSI'N, DIMENSIONLESS       (Q) 0.99999998E-02
     REINFORCING DISTANCE, IN.                            (D)  3.3000000

     DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  3.2500000
     PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLK)  5.0000000
     EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.8000000
     LENGTH OF EXPLOSIVE, IN.                          (BIGL)  5.6300001

     X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
     X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
     Y 1 OF EXPLOSIVE, IN.                              (EY1)  23.400000
     Y 2 OF EXPLOSIVE, IN.                              (EY2)  27.799999

     Z 1 OF EXPLOSIVE, IN.                              (EZ1)  23.000000
     Z 2 OF EXPLOSIVE, IN.                              (EZ2)  23.000000
     SHEAR STIRRUP REINFORMENT RATIO                     (Q1) 0.49999999E-04
     ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLA)  2.0000000

     TIME INCREMENT, SEC.                             (TINCR) 0.99999997E-04
     TIME MAXIMUM, SEC.                                (TMAX) 0.10000000
     TIME STEP INTERVAL PER PRINTED LINE, SEC.      (TPRINT) 0.50000002E-03
     CRITICAL TIME, SEC.                                (TCR) 0.14000000E-02

COMPUTED CONSTANT VALUES
     BEAM HALF WIDTH, IN.                                 (B)  24.920000
     HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  5882.0205
     WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W) 0.34721902
     ORIGINAL HINGE LOCATION, IN.                        (XH)  21.438419

     CLAMPED-SUPPORTED          GENERAL TIME FUNCTION          VERTICAL WALL                  BLAST LOAD
```

TABLE I-13. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB6-2.8 POUND AT 23 INCHES (Continued).

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEB6--2.8 LB. AT 23 IN. 3 27 1990 9 57 0 20

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.24833298	1.7538495

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEB6--2.8 LB. AT 23 IN. 3 27 1990 9 57 0 59

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	21.438419
0.49999997E-03	0.34029726E-02	180.78674	0.80750100E-01	19713.705	3990.4602	15723.245	23.729282
0.99999993E-03	0.65223733E-02	180.78674	0.17114347	19713.705	7648.3926	12065.312	26.239447
0.14999997E-02	0.90929717E-02	131.04074	0.25460321	19713.705	10662.777	9050.9277	28.000000
0.19999994E-02	0.11209345E-01	105.99317	0.31386167	19713.705	13144.522	6569.1826	28.000000
0.24999997E-02	0.12878442E-01	80.945602	0.36059639	19713.705	15101.771	4611.9346	28.000000
0.30000000E-02	0.14100260E-01	55.898037	0.39480728	19713.705	16534.521	3179.1836	28.000000
0.35000003E-02	0.14874800E-01	30.850407	0.41649440	19713.705	17442.777	2270.9277	28.000000
0.40000007E-02	0.15202063E-01	5.8029332	0.42565778	19713.705	17826.537	1887.1680	28.000000

MAXIMUM DEFLECTION = 0.42581645 AT TIME = 0.42000003E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-14. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC1-2.4 POUND AT 6 INCHES.

```
                                                                                  PAGE  1
CALCULATIONS ON A CONCRETE BEAM                                     3  27 1990   9  59  22  35

AFESC CASEC1--2.4 LB. AT 6 IN.

INPUT VALUES

   PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                 (A)  28.000000
   BEAM OR PLATE THICKNESS, IN.                            (H)  4.0000000
   LENGTH TO WIDTH RATIO, DIMENSIONLESS                   (AR) 0.88999999
   MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED           (SMALLM) 0.10783300E-02

   POWER FROM PRESSURE-LAMBDA CURVE                       (FN) 0.82999998
   UNIFORM PRESSURE LOAD, PSI.                            (PU) 0.00000000E+00
   PRESSURE DECAY, DIMENSIONLESS                       (ALPHA)  3.4000001
   PRESSURE DURATION, SEC.                               (TAU) 0.23500000E-03

   SUPPORT FACTOR: 1=SIM Y, 2=CLAMPED                      (F)  2.0000000
   WAVE FUNCTION: 1=GENERAL, 2=SQUARE                 (WAVEFN)  1.0000000
   WEIGHT VECTOR: O=VERT, 1=EXP BLW, -1=EXP AB(SMALLN) 0.00000000E+00
   REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4            (RHOR) 0.73390000E-03

   CONCRETE COMPRESSIVE STRENGTH, PSI.                (SIGMAC)  5000.0000
   REINFORCED STEEL YIELD STRESS, PSI.                (SIGMAR)  65000.000
   REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS    (Q) 0.16500000E-01
   REINFORCING DISTANCE, IN.                               (D)  3.0999999

   DIAMETER OF EXPLOSIVE, IN.                          (BIGD)  2.5000000
   PRESSURE INTERCEPT ON P-LAMBDA CURVE              (SMALLK)  5.0000000
   EXPLOSIVE WEIGHT, LBS.                              (BIGW)  2.4000001
   LENGTH OF EXPLOSIVE, IN.                            (BIGL)  8.1499996

   X 1 OF EXPLOSIVE, IN.                                (EX1)  28.000000
   X 2 OF EXPLOSIVE, IN.                                (EX2)  28.000000
   Y 1 OF EXPLOSIVE, IN.                                (EY1)  20.900000
   Y 2 OF EXPLOSIVE, IN.                                (EY2)  29.100000

   Z 1 OF EXPLOSIVE, IN.                                (EZ1)  6.0000000
   Z 2 OF EXPLOSIVE, IN.                                (EZ2)  6.0000000
   SHEAR STIRRUP REINFORMENT RATIO                       (Q1) 0.00000000E+00
   ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                 (SMALLA)  2.0000000

   TIME INCREMENT, SEC.                               (TINCR) 0.99999997E-04
   TIME MAXIMUM, SEC.                                  (TMAX) 0.10000000
   TIME STEP INTERVAL PER PRINTED LINE, SEC.        (TPRINT) 0.50000002E-03
   CRITICAL TIME, SEC.                                  (TCR) 0.20999999E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
    BEAM HALF WIDTH, IN.                                   (B)  24.920000
    HINGE MOMENT, IN.-LBS./IN.                        (BIGMU)  8102.1211
    WEIGHT PER UNIT AREA, LBS./IN.SQ.                      (W) 0.41666669
```

TABLE I-14. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC1-2.4 POUND AT 6 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEC1--2.4 LB. AT 6 IN. 3 27 1990 9 59 25 15

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	2.5839610	2.3317571
3.6249993	1.3283942	2.3317571

BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 3.62500 IN.

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEC1--2.4 LB. AT 6 IN. 3 27 1990 9 59 28 89

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.66390298E-02	394.79163	0.18589284	87468.422	10723.620	76744.805	28.000000
0.99999993E-03	0.13432175E-01	366.04065	0.37610090	87468.422	21696.172	65772.250	28.000000
0.14999997E-02	0.19711910E-01	337.28964	0.55193347	87468.422	31839.443	55628.977	28.000000
0.19999994E-02	0.25478235E-01	308.53864	0.71339059	87468.422	41153.434	46314.988	28.000000
0.24999997E-02	0.30731147E-01	279.78766	0.86047214	87468.422	49638.141	37830.281	28.000000
0.30000000E-02	0.35470650E-01	251.03667	0.99317819	87468.422	57293.570	30174.852	28.000000
0.35000003E-02	0.39696742E-01	222.28569	1.1115087	87468.422	64119.719	23348.703	28.000000
0.40000007E-02	0.43409426E-01	193.53476	1.2154639	87468.422	70116.586	17351.836	28.000000
0.44999998E-02	0.46608698E-01	164.78384	1.3050436	87468.422	75284.164	12184.258	28.000000
0.49999990E-02	0.49294565E-01	136.03291	1.3802478	87468.422	79622.484	7845.9375	28.000000
0.54999981E-02	0.51467016E-01	107.28198	1.4410765	87468.422	83131.508	4336.9141	28.000000
0.59999973E-02	0.53126063E-01	78.531021	1.4875298	87468.422	85811.273	1657.1484	28.000000
0.64999964E-02	0.54271694E-01	49.780064	1.5196074	87468.422	87661.742	-193.32031	28.000000
0.69999956E-02	0.54903921E-01	21.029110	1.5373098	87468.422	88682.937	-1214.5156	28.000000

MAXIMUM DEFLECTION = 1.5411212 AT TIME = 0.73999949E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-15. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC2-2.4 POUND AT 12 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                       PAGE 1

AFESC CASEC2--2.4 LB. AT 12 IN.                                      3  27 1990    9  59  36  25

INPUT VALUES

   PLATE HALF WIDTH OR BEAM HALF SPAN, IN.              (A)  28.000000
   BEAM OR PLATE THICKNESS, IN.                         (H)  4.0000000
   LENGTH TO WIDTH RATIO, DIMENSIONLESS                (AR) 0.88999999
   MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED        (SMALLM) 0.10782999E-02

   POWER FROM PRESSURE-LAMBDA CURVE                    (FN)  1.0000000
   UNIFORM PRESSURE LOAD, PSI.                         (PU) 0.00000000E+00
   PRESSURE DECAY, DIMENSIONLESS                    (ALPHA)  3.5000000
   PRESSURE DURATION, SEC.                            (TAU) 0.20200000E-03

   SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                  (F)  2.0000000
   WAVE FUNCTION: 1=GENERAL, 2=SQUARE              (WAVEFN)  1.0000000
   WEIGHT VECTOR: O=VERT, 1=EXP BLW, -1=EXP AB(SMALLN) 0.00000000E+00
   REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4         (RHOR) 0.73390000E-03

   CONCRETE COMPRESSIVE STRENGTH, PSI.             (SIGMAC)  5000.0000
   REINFORCED STEEL YIELD STRESS, PSI.             (SIGMAR)  65000.000
   REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS      (Q) 0.16500000E-01
   REINFORCING DISTANCE, IN.                            (D)  3.0999999

   DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  2.5000000
   PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLK)  5.0000000
   EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.4000001
   LENGTH OF EXPLOSIVE, IN.                          (BIGL)  8.1499996

   X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
   X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
   Y 1 OF EXPLOSIVE, IN.                              (EY1)  20.900000
   Y 2 OF EXPLOSIVE, IN.                              (EY2)  29.100000

   Z 1 OF EXPLOSIVE, IN.                              (EZ1)  12.000000
   Z 2 OF EXPLOSIVE, IN.                              (EZ2)  12.000000
   SHEAR STIRRUP REINFORMENT RATIO                     (Q1) 0.00000000E+00
   ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLA)  2.0000000

   TIME INCREMENT, SEC.                             (TINCR) 0.99999997E-04
   TIME MAXIMUM, SEC.                                (TMAX) 0.10000000
   TIME STEP INTERVAL PER PRINTED LINE, SEC.       (TPRINT) 0.50000002E-03
   CRITICAL TIME, SEC.                                (TCR) 0.20999999E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (O,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
   BEAM HALF WIDTH, IN.                                 (B)  24.920000
   HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  8102.1211
   WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W) 0.41665509
```

TABLE I-15. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC2-2.4 POUND AT 12 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEC2--2.4 LB. AT 12 IN. 3 27 1990 9 59 39 10

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.73228115	2.3317261

CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEC2--2.4 LB. AT 12 IN. 3 27 1990 9 59 39 71

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.49999997E-03	0.44447631E-02	255.43737	0.12445337	38563.246	7179.3545	31383.891	28.000000
0.99999993E-03	0.87494412E-02	226.68607	0.24438436	38563.246	14132.437	24430.809	28.000000
0.14999997E-02	0.12540634E-01	197.93434	0.35113943	38563.246	20256.219	18307.027	28.000000
0.19999994E-02	0.15818523E-01	169.18262	0.44291866	38563.246	25550.699	13012.547	28.000000
0.24999997E-02	0.18582929E-01	140.43089	0.52032202	38563.246	30015.875	8547.3711	28.000000
0.30000000E-02	0.20833911E-01	111.67916	0.58334953	38563.246	33651.754	4911.4922	28.000000
0.35000003E-02	0.22571471E-01	82.927399	0.63200116	38563.246	36458.324	2104.9219	28.000000
0.40000007E-02	0.23795605E-01	54.175640	0.66627693	38563.246	38435.590	127.65625	28.000000
0.44999998E-02	0.24506314E-01	25.423882	0.68617678	38563.246	39583.559	-1020.3125	28.000000

MAXIMUM DEFLECTION = 0.69170082 AT TIME = 0.49999990E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-16. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC3-2.4 POUND AT 18 INCHES.

CALCULATIONS ON A CONCRETE BEAM

PAGE 1

AFESC CASEC3--2.4 LB. AT 18 IN.

3 27 1990 9 59 49 87

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN.	(L)	28.000000
BEAM OR PLATE THICKNESS, IN.	(H)	4.0000000
LENGTH TO WIDTH RATIO, DIMENSIONLESS	(AK)	0.08939999
MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED	(SMALLM)	0.10782999E-02
POWER FROM PRESSURE-LAMBDA CURVE	(FN)	1.1500000
UNIFORM PRESSURE LOAD, PSI.	(PU)	0.00000000E+00
PRESSURE DECAY, DIMENSIONLESS	(ALPHA)	4.3000002
PRESSURE DURATION, SEC.	(TAU)	0.26199999E-03
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED	(F)	2.0000000
WAVE FUNCTION: 1=GENERAL, 2=SQUARE	(WAVEFN)	1.0000000
WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB	(SMALLN)	0.00000000E+00
REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4	(RHOR)	0.73390000E-03
CONCRETE COMPRESSIVE STRENGTH, PSI.	(SIGMAC)	50[illegible].0000
REINFORCED STEEL YIELD STRESS, PSI.	(SIGMAR)	65000.000
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS	(Q)	0.16500000E-01
REINFORCING DISTANCE, IN.	(D)	3.0999999
DIAMETER OF EXPLOSIVE, IN.	(BIGD)	2.5000000
PRESSURE INTERCEPT ON P-LAMBDA CURVE	(SMALLL)	5.0000000
EXPLOSIVE WEIGHT, LBS.	(BIGW)	2.4000001
LENGTH OF EXPLOSIVE, IN.	(BIGL)	8.1439996
X 1 OF EXPLOSIVE, IN.	(EX1)	28.000000
X 2 OF EXPLOSIVE, IN.	(EX2)	28.000000
Y 1 OF EXPLOSIVE, IN.	(EY1)	20.900000
Y 2 OF EXPLOSIVE, IN.	(EY2)	29.100000
Z 1 OF EXPLOSIVE, IN.	(EZ1)	18.000000
Z 2 OF EXPLOSIVE, IN.	(EZ2)	18.000000
SHEAR STIRRUP REINFORMENT RATIO	(U1)	0.00000000E+00
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR	(SMALLA)	2.0000000
TIME INCREMENT, SEC.	(TINCR)	0.99999997E-04
TIME MAXIMUM, SEC.	(TMAX)	0.10000000
TIME STEP INTERVAL PER PRINTED LINE, SEC.	(TPRINT)	0.50000002E-03
CRITICAL TIME, SEC.	(TCR)	0.20999999E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN.	(B)	24.920000
HINGE MOMENT, IN.-LBS./IN.	(BIGMU)	8102.1211
WEIGHT PER UNIT AREA, LBS./IN.SQ.	(W)	0.41665509
ORIGINAL HINGE LOCATION, IN.	(XH)	26.231281

CLAMPED-SUPPORTED GENERAL TIME FUNCTION : VERTICAL WALL BLAST LOAD

TABLE I-16. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC3-2.4 POUND AT 18 INCHES (Continued).

```
                                                                                           PAGE  2
   CALCULATIONS IN A CONCRETE BEAM     LOCALIZED SHEAR FAILURE CALCULATION
                                                                          3  27 1990   10   0   1  29
  AFESC CASEC3--2.4 LB. AT 18 IN.

   CLAMPED-SUPPORTED        GENERAL TIME FUNCTION          VERTICAL WALL               BLAST LOAD

BREACH RADIUS   I BAR       I CRITICAL

1.0000000     0.35389426    2.3317261
                                                                                           PAGE  3
   CALCULATIONS IN A CONCRETE BEAM     FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE
                                                                          3  27 1990   10   0   1  35
  AFESC CASEC3--2.4 LB. AT 18 IN.

   CLAMPED-SUPPORTED        GENERAL TIME FUNCTION          VERTICAL WALL               BLAST LOAD
```

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	26.231291
0.49399997E-03	0.31417271E-02	178.78029	0.87968357E-01	20825.404	5074.6396	15750.765	28.000000
0.99399993E-03	0.60775205E-02	150.02056	0.17017058	20825.404	9816.6475	11008.757	28.000000
0.14399997E-02	0.84998906E-02	121.27683	0.23799694	20825.404	13729.353	7096.0518	28.000000
0.19399994E-02	0.10408836E-01	92.525085	0.29144743	20825.404	16812.756	4012.6484	28.000000
0.24399997E-02	0.11804358E-01	63.773323	0.33052203	20825.404	19066.857	1758.5469	28.000000
0.30000000E-02	0.12686456E-01	35.021561	0.35522076	20825.404	20491.654	333.75000	28.000000
0.35000003E-02	0.13055129E-01	6.2698092	0.36554360	20825.404	21087.150	-261.74609	28.000000

MAXIMUM DEFLECTION = 0.36564749   AT TIME = 0.37000005E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-17. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC4-2.8 POUND AT 7 INCHES.

```
                                                                                          PAGE  1
CALCULATIONS ON A CONCRETE BEAM                                          3  27 1980   10   0  24  80

AFESC CASEC4--2.8 LB. AT 7 IN.

INPUT VALUES

  PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                   (A)  28.000000
  BEAM OR PLATE THICKNESS, IN.                              (H)  4.0000000
  LENGTH TO WIDTH RATIO, DIMENSIONLESS                     (AK)  0.88999999
  MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED             (SMALLM)  0.10782999E-02

  POWER FROM PRESSURE-LAMBDA CURVE                         (FN)  1.0000000
  UNIFORM PRESSURE LOAD, PSI.                              (PU)  0.00000000E+00
  PRESSURE DECAY, DIMENSIONLESS                         (ALPHA)  3.4000001
  PRESSURE DURATION, SEC.                                 (TAU)  0.24500000E-03

  SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                       (F)  2.0000000
  WAVE FUNCTION: 1=GENERAL, 2=SQUARE                   (WAVEFN)  1.0000000
  WEIGHT VECTOR: 0=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
  REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4              (RHOR)  0.73390000E-03

  CONCRETE COMPRESSIVE STRENGTH, PSI.                  (SIGMAC)  5000.0000
  REINFORCED STEEL YIELD STRESS, PSI.                  (SIGMAR)  65000.000
  REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS            (Q)  0.16500000E-01
  REINFORCING DISTANCE, IN.                                 (D)  3.0999999

  DIAMETER OF EXPLOSIVE, IN.                             (BIGD)  3.2500000
  PRESSURE INTERCEPT ON P-LAMBDA CURVE                 (SMALLC)  5.0000000
  EXPLOSIVE WEIGHT, LBS.                                 (BIGW)  2.8000000
  LENGTH OF EXPLOSIVE, IN.                               (BIGL)  5.6300001

  X 1 OF EXPLOSIVE, IN.                                   (EX1)  28.000000
  X 2 OF EXPLOSIVE, IN.                                   (EX2)  28.000000
  Y 1 OF EXPLOSIVE, IN.                                   (EY1)  23.400000
  Y 2 OF EXPLOSIVE, IN.                                   (EY2)  27.799999

  Z 1 OF EXPLOSIVE, IN.                                   (EZ1)  7.0000000
  Z 2 OF EXPLOSIVE, IN.                                   (EZ2)  7.0000000
  SHEAR STIRRUP REINFORCEMENT RATIO                        (Q1)  0.00000000E+00
  ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                    (SMALLA)  2.0000000

  TIME INCREMENT, SEC.                                  (TINCR)  0.99999997E-04
  TIME MAXIMUM, SEC.                                     (TMAX)  0.16000000
  TIME STEP INTERVAL PER PRINTED LINE, SEC.            (TPRINT)  0.50000002E-03
  CRITICAL TIME, SEC.                                     (TCR)  0.20999999E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,A).
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES
  BEAM HALF WIDTH, IN.                                      (B)  24.920000
  HINGE MOMENT, IN.-LBS./IN.                            (BIGMO)  8102.1211
  WEIGHT PER UNIT AREA, LBS./IN.SQ.                         (W)  0.41665509
```

TABLE I-17. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC4-2.8 POUND AT 7 INCHES (Continued).

ORIGINAL HINGE LOCATION, IN. (XH) 28.000000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

CALCULATIONS IN A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION PAGE 2

AFESC CASEC4--2.8 LB. AT 7 IN. 3 27 1990 10 0 27 11

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

BREECH RADIUS	I BAR	I CRITICAL
1.0000000	1.1107665	2.3317261

CALCULATIONS IN A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE PAGE 3

AFESC CASEC4--2.8 LB. AT 7 IN. 3 27 1990 10 0 27 49

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	28.000000
0.43399997E-03	0.57374225E-02	340.92096	0.16064782	66653.289	9267.3076	57385.960	28.000000
0.99399993E-03	0.11560584E-01	312.16919	0.32392037	66653.289	18686.027	47967.262	28.000000
0.14399997E-02	0.18886320E-01	283.41739	0.47281694	66653.289	27275.441	39377.848	28.000000
0.19399994E-02	0.21690633E-01	254.66559	0.60733771	66653.289	35035.555	31617.734	28.000000
0.24399997E-02	0.25981521E-01	225.91379	0.72748262	66653.289	41966.359	24686.930	28.000000
0.30000000E-02	0.29758984E-01	197.16206	0.83325154	66653.289	48067.963	18585.426	28.000000
0.35000003E-02	0.33023022E-01	168.41034	0.92464459	66653.289	53340.070	13313.219	28.000000
0.40000007E-02	0.35773639E-01	139.65862	1.0016619	66653.289	57782.973	8870.3164	28.000000
0.44399998E-02	0.38010828E-01	110.90688	1.0643032	66653.289	61396.566	5256.7227	28.000000
0.49399990E-02	0.39734535E-01	82.155121	1.1125696	66653.289	64180.863	2472.4258	28.000000
0.54399981E-02	0.40944941E-01	53.403566	1.1464584	66653.289	66135.859	517.42969	28.000000
0.59399973E-02	0.41641861E-01	24.651608	1.1659721	66653.289	67261.562	-608.27344	28.000000

MAXIMUM DEFLECTION = 1.1711099 AT TIME = 0.64999964E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-18. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC5-2.8 POUND AT 16 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                                         PAGE  1

AFESC CASEC5--2.8 LB. AT 16 IN.                                                  3  27 1990    10   0   31   45

INPUT VALUES

     PLATE HALF WIDTH OR BEAM HALF SPAN, IN.                (A)  28.000000
     BEAM OR PLATE THICKNESS, IN.                           (H)  4.0000000
     LENGTH TO WIDTH RATIO, DIMENSIONLESS                  (AK)  0.88939939
     MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED          (SMALLM)  0.10782939E-02

     POWER FROM PRESSURE-LAMBDA CURVE                      (FN)  1.1500000
     UNIFORM PRESSURE LOAD, PSI.                           (PU)  0.00000000E+00
     PRESSURE DECAY, DIMENSIONLESS                      (ALPHA)  3.8000000
     PRESSURE DURATION, SEC.                              (TAU)  0.23400001E-03

     SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                    (F)  2.0000000
     WAVE FUNCTION: 1=GENERAL, 2=SQUARE                (WAVEFN)  1.0000000
     WEIGHT VECTOR: O=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
     REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4           (RHOR)  0.73390000E-03

     CONCRETE COMPRESSIVE STRENGTH, PSI.              (SIGMAC)  5000.0000
     REINFORCED STEEL YIELD STRESS, PSI.              (SIGMAR)  65000.000
     REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS         (Q)  0.16500000E-01
     REINFORCING DISTANCE, IN.                             (D)  3.0999999

     DIAMETER OF EXPLOSIVE, IN.                          (BIGD)  3.2500000
     PRESSURE INTERCEPT ON P-LAMBDA CURVE              (SMALLK)  5.0000000
     EXPLOSIVE WEIGHT, LBS.                              (BIGW)  2.8000000
     LENGTH OF EXPLOSIVE, IN.                            (BIGL)  5.6300001

     X 1 OF EXPLOSIVE, IN.                                (EX1)  28.000000
     X 2 OF EXPLOSIVE, IN.                                (EX2)  28.000000
     Y 1 OF EXPLOSIVE, IN.                                (EY1)  23.400000
     Y 2 OF EXPLOSIVE, IN.                                (EY2)  27.799999

     Z 1 OF EXPLOSIVE, IN.                                (EZ1)  16.000000
     Z 2 OF EXPLOSIVE, IN.                                (EZ2)  16.000000
     SHEAR STIRRUP REINFORMENT RATIO                       (Q1)  0.00000000E+00
     ENVIRONMENT FACTOR: 1=SOIL, 2=AIR                 (SMALLA)  2.0000000

     TIME INCREMENT, SEC.                               (TINCR)  0.99999997E-04
     TIME MAXIMUM, SEC.                                  (TMAX)  0.10000000
     TIME STEP INTERVAL PER PRINTED LINE, SEC.         (TPRINT)  0.50000002E-03
     CRITICAL TIME, SEC.                                  (TCR)  0.20999999E-02

COMPUTED CONSTANT VALUES
     BEAM HALF WIDTH, IN.                                   (B)  24.920000
     HINGE MOMENT, IN.-LBS./IN.                          (BIGMU)  8102.1211
     WEIGHT PER UNIT AREA, LBS./IN.SQ.                      (W)  0.41665509
     ORIGINAL HINGE LOCATION, IN.                          (XH)  26.971539

     CLAMPED-SUPPORTED         GENERAL TIME FUNCTION          VERTICAL WALL            BLAST LOAD
```

TABLE I-18. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC5-2.8 POUND AT 16 INCHES (Continued).

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION   PAGE 2

AFESC CASEC5--2.8 LB. AT 16 IN.   3 27 1990 10 0 38 37

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.45191664	2.3317261

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE   PAGE 3

AFESC CASEC5--2.8 LB. AT 16 IN.   3 27 1990 10 0 38 97

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	26.971539
0.49999997E-03	0.36720552E-02	210.88486	0.10281754	27613.783	5931.2461	21682.537	28.000000
0.99999993E-03	0.71811439E-02	182.13313	0.20107202	27613.783	11599.263	16014.521	28.000000
0.14999997E-02	0.10176809E-01	153.38141	0.28495064	27613.783	16437.979	11175.805	28.000000
0.19999994E-02	0.12659051E-01	124.62968	0.35445341	27613.783	20447.393	7166.3906	28.000000
0.24999997E-02	0.14627068E-01	95.877930	0.40958032	27613.783	23627.504	3986.2793	28.000000
0.30000000E-02	0.16083261E-01	67.126167	0.45033130	27613.783	25978.314	1635.4687	28.000000
0.35000003E-02	0.17025230E-01	38.374409	0.47670645	27613.783	27499.818	113.96484	28.000000
0.40000007E-02	0.17453775E-01	9.6226568	0.48870569	27613.783	28192.021	-578.23828	28.000000

MAXIMUM DEFLECTION = 0.48948020   AT TIME = 0.42000003E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

TABLE I-19. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC6-2.8 POUND AT 23 INCHES.

```
CALCULATIONS ON A CONCRETE BEAM                                                              PAGE  1

AFESC CASEC6--2.8 LB. AT 23 IN.                                          3  27 1990   10   0   49   8

INPUT VALUES

  PLATE HALF WIDTH OR BEAM HALF SPAN, IN.              (A)  28.000000
  BEAM OR PLATE THICKNESS, IN.                         (H)  4.0000000
  LENGTH TO WIDTH RATIO, DIMENSIONLESS                (AR)  0.88999999
  MASS PER UNIT AREA, LBS-SEC.SQD/IN.CUBED        (SMALLM)  0.10782999E-02

  POWER FROM PRESSURE-LAMBDA CURVE                    (FN)  1.2500000
  UNIFORM PRESSURE LOAD, PSI.                         (PU)  0.00000000E+00
  PRESSURE DECAY, DIMENSIONLESS                    (ALPHA)  5.4000001
  PRESSURE DURATION, SEC.                            (TAU)  0.37299999E-03

  SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED                  (F)  2.0000000
  WAVE FUNCTION: 1=GENERAL, 2=SQUARE              (WAVEFN)  1.0000000
  WEIGHT VECTOR: O=VERT, 1=EXP BLW, -1=EXP AB(SMALLN)  0.00000000E+00
  REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.**4         (RHOR)  0.73390000E-03

  CONCRETE COMPRESSIVE STRENGTH, PSI.             (SIGMAC)  5000.0000
  REINFORCED STEEL YIELD STRESS, PSI.             (SIGMAR)  65000.000
  REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS      (Q)  0.16500000E-01
  REINFORCING DISTANCE, IN.                            (D)  3.0999999

  DIAMETER OF EXPLOSIVE, IN.                        (BIGD)  3.2500000
  PRESSURE INTERCEPT ON P-LAMBDA CURVE            (SMALLK)  5.0000000
  EXPLOSIVE WEIGHT, LBS.                            (BIGW)  2.8000000
  LENGTH OF EXPLOSIVE, IN.                          (BIGL)  5.6300001

  X 1 OF EXPLOSIVE, IN.                              (EX1)  28.000000
  X 2 OF EXPLOSIVE, IN.                              (EX2)  28.000000
  Y 1 OF EXPLOSIVE, IN.                              (EY1)  23.400000
  Y 2 OF EXPLOSIVE, IN.                              (EY2)  27.799999

  Z 1 OF EXPLOSIVE, IN.                              (EZ1)  23.000000
  Z 2 OF EXPLOSIVE, IN.                              (EZ2)  23.000000
  SHEAR STIRRUP REINFORMENT RATIO                     (Q1)  0.00000000E+00
  ENVIRONMENT FACTOR: 1=SOIL, 2=AIR               (SMALLA)  2.0000000

  TIME INCREMENT, SEC.                             (TINCR)  0.99999997E-04
  TIME MAXIMUM, SEC.                                (TMAX)  0.10000000
  TIME STEP INTERVAL PER PRINTED LINE, SEC.       (TPRINT)  0.50000002E-03
  CRITICAL TIME, SEC.                                (TCR)  0.20999999E-02

COMPUTED CONSTANT VALUES
  BEAM HALF WIDTH, IN.                                 (B)  24.920000
  HINGE MOMENT, IN.-LBS./IN.                       (BIGMU)  8102.1211
  WEIGHT PER UNIT AREA, LBS./IN.SQ.                    (W)  0.41665509
  ORIGINAL HINGE LOCATION, IN.                        (XH)  21.774929

  CLAMPED-SUPPORTED         GENERAL TIME FUNCTION        VERTICAL WALL         BLAST LOAD
```

TABLE I-19. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC6-2.8 POUND AT 23 INCHES (Continued).

PAGE 2

CALCULATIONS ON A CONCRETE BEAM   LOCALIZED SHEAR FAILURE CALCULATION

3 27 1990 10 0 56 38

AFESC CASEC6--2.8 LB. AT 23 IN.

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

BREACH RADIUS	I BAR	I CRITICAL
1.0000000	0.24017607	2.3317261

PAGE 3

CALCULATIONS ON A CONCRETE BEAM   FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE

3 27 1990 10 0 56 77

AFESC CASEC6--2.8 LB. AT 23 IN.

CLAMPED-SUPPORTED   GENERAL TIME FUNCTION   VERTICAL WALL   BLAST LOAD

TIME (SECONDS)	THETA (RADIANS)	MIDPT. VEL. (IN./SEC.)	MIDPT. DELTA (INCHES)	PRESSURE WORK (IN.-LBS.)	PLASTIC WORK (IN.-LBS.)	KINETIC ENERGY (IN.-LBS.)	HINGE LOCATION (INCHES)
0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	21.774929
0.49999997E-03	0.27153083E-02	151.15950	0.67512698E-01	16232.978	4386.0005	11846.977	24.862999
0.99999993E-03	0.50654346E-02	115.73785	0.14103217	16232.978	8181.8057	8051.0918	28.000000
0.14999997E-02	0.68754690E-02	86.986099	0.19251315	16232.978	11105.525	5127.4521	28.000000
0.19999994E-02	0.81720809E-02	58.234537	0.22881827	16232.978	13199.862	3033.1152	28.000000
0.24999997E-02	0.89552673E-02	29.482578	0.25074747	16232.978	14464.896	1768.0820	28.000000
0.30000000E-02	0.92250295E-02	0.73082530	0.25830084	16232.978	14900.626	1332.3516	28.000000

MAXIMUM DEFLECTION = 0.25808638   AT TIME = 0.31000001E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

1

(The reverse side of this page is blank.)